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Four essays on the impact of front-of-pack labels in consumer decision-making for healthier and more informed food choices

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AUTHOR'S DECLARATION

I, Marco Francesco Mazzù declare that this thesis, titled "Four essays on the impact of front-of-pack labels in consumer decision-making for healthier and more informed food choices", submitted in partial fulfilment of the requirements for the award of Doctor of Philosophy, in the Department of Economics at the University of Messina, Italy, is my own work unless otherwise referenced or acknowledged. In addition, I confirm that:

- This work was done while in candidature for a research degree at this University.
- Where I have consulted the published work of others, this is clearly attributed.
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Introduction

The soar of overweight and obesity, nearly tripling since 1975, is becoming one of the most pressing global issues for the health, with consequences on several noncommunicable diseases[1], and a relevant impact on direct and indirect costs of Public Health Systems. Therefore, governmental bodies and food industry players increased their willingness in helping consumers in making healthier and more informed food choices, activating several institutional corrective and preventive actions[2].

An important policy measure has been the introduction of Front-of-Pack nutritional Labels[3] (also, in the acronyms, FOPLs or FOP labels), simplified nutrition information provided on the front of food packaging aiming to help consumers with their food choices. Their presence increases consumers' assessment of product's nutrition information and of perception of specific Nutritional Items[4] (Findling *et al.*, 2018), improves consumers' ability to identify food healthier options (e.g., Hawley *et al.*, 2013), and has been judged helpful by consumers to achieve a more balanced dietary regime.

In the last decades, countries have adopted different typologies of FOPLs (Kanter *et al.*, 2018), ranging from easy-to-decodify ones - that support rapid decision-making - *vs.* FOPLs with an adequate level of information that enable consumers' more conscious choices in food selection. This resulted in Summary labels, with a more "*directive*" approach, that sum-up the healthiness of the product and provide qualitative recommendations through colors and symbols without showing details on nutritional items, as opposed to Nutrient-Specific ones, more "*informative*", that show nutritional details, without any recommendation, opinion or judgments. The heterogeneity of the many types of FOPLs today present in the market, stimulated an important international debate on (a) the relative effectiveness of different labels to support consumers in their healthier and more informed food choices, and (b) the need to find one harmonized mandatory FOPL, driven by the EU "*Farm-to-Fork*" strategy, that could be utilized across the European Union.

Extant academic research contributed to the debate, by assessing the effects of different FOPLs on consumers' decision-making in food. Part of the studies pay particular attention to

[1] E.g., cardiovascular diseases, diabetes, muscolosketal disorders, some cancers (WHO, 2020)
[2] E.g., among others, in 2006 the Association of the European food and drink industry introduced the Guideline Daily Amounts (GDA) scheme, later renamed Reference Intakes label, with numerical info on how much energy and nutrients are present in a portion of a food and how much this represents as a percentage of the daily reference intake. In 2008, the EU signaled the need of introducing Front-of-Pack (FoP) indication in pre-packaged foods. In 2011, the EU introduced the Regulation EU 1169/2011, currently the main law relating to food labelling in the EU, including mandatory food information and the list of elements on the "back-of-food" packaging. In 2016, the EU Food Information to Consumers (FIC) highlighted that Back-of-pack information should be complemented by a non-mandatory repetition of its main elements in the Front-of-Pack, in order to help consumers to make informed and health-conscious choices
3 FOPL are defined as labels that carry nutritional information on the front of the packaging of food products that are not Nutrition Facts Panel (NFP) (van der Bend & Lissner, 2019)
4 E.g., salt, sugar and fats

how consumers use FOPLs in their decision-making processes. The theoretical paradigm of reference for most of these studies considers the consumer as an individual active in obtaining information from the environment and in orienting his/her behavior of choice with the aim of pursuing own ends of consumption (Grunert & Wills, 2007). The behavior in response to FOPLs can therefore be explained by adopting the perspective that describes interactions between individuals and the environment, i.e., marketing stimuli, including products and communication. The structure of this process describing antecedents and its consequences of consumption behavior in food foresees, in a simplified manner, the series of steps of attention/exposure, perception, (*objective* and *subjective*) understanding, liking, and use (Grunert & Wills, 2007). The hypothesis that the reference model assumes regarding the cognitive system of individuals is the presence of an interaction between information coming from the environment and the knowledge stored in memory: a dynamic and repeated comparison between input received and knowledge acquired. Within these models, most of the consumer's cognitive processes are based on knowledge that the consumer keeps in memory and how it evolves over time (Nelson & Shiffrin, 2013; Cox & Shiffrin, 2017). The individual cognitive system can basically collect any type of external stimulus and transform it into knowledge, meanings and beliefs. These, in turn, are organized in associative networks, that evolve and change as a result of the learning processes. Finally, based on the cognitive processes and information present in the memory, individuals produce final and summary evaluations capable of directing subsequent consumption choices and behaviors. Given the general cognitive process described above, it is, therefore, possible to adapt it to the specific context of the FOP (Front-of-Pack) labels, with a first phase on the exposure of FOPL, followed by the attention, the understanding of the FOPL, the storage of the information, the acceptance and the post-evaluation after product choice. In this flow, synthesized in the adapted Grunert & Wills (2007), two streams of research converge: the one on *consumer decision-making* (Peter et al., 1999; Solomon et al., 2006, Bettman, 1979; Bettman et al., 1998), which "*deals with the processes determining product choice in a situation where multiple options are available*", each with a different FOP label, and aims to understand how the choice is influenced, including concerning the information provided on the label; and the one on *attitude formation and change* (Eagly & Chaiken, 1993, Mcguire, 1985; Petty & Cacioppo, 1981), which concerns with "*how consumers process the information on the labels to which they are exposed*", make sense of it and evaluate whether it has a positive or negative meaning in a subjective perspective, which part of it is usually considered a prerequisite for the information to affect behavior. When the

consumer is, for example, in front of the supermarket shelf, he/she adopts an information process which is divided into various steps, and which can be interrupted at any time if the stimulus is not strong enough.

An effective label must be designed in a way that catalyzes the consumers' cognitive exposure, draws their attention, and is easily coded and understood (DeJoy, 1991); only then can the label influence the decision-making process. Therefore, in order to be effective, each label must pass the various stages of the cognitive process described above. In fact, the mere insertion of information on a package does not guarantee its use by the consumer. The information must be assimilated through the senses and even if the signal is successfully encoded if it is in a language that is not familiar to the consumer or the reading complexity is beyond his/her comprehension or the information is expressed in a confused way, the whole process can fail (Becker *et al.*, 2015). Each phase is relevant in the consumer's cognitive process in relationship to the stimuli generated by FOPLs. During exposure, which can be accidental, consumers might search for FOPLs' information. The active process starts with the attention phase, being the first step that really involves the consumer. However, attention only affects behavior when the information is actually understood, where *understanding* is the meaning the consumer attaches to the stimulus, in the specific case the FOPL, of what is perceived. In addition, *liking* of the FOPL also plays an important role, differentiated and complementary to the one of *understanding*, as it might generate a positive product's assessment, regardless of the level of understanding, and contribute in affecting consumers' choices. In fact, the design of a label must activate the consumer's attention, otherwise the elaboration of the nutritional information will be ignored at the beginning of the process without ever reaching the stage of understanding/ usability of the information, where visual attention has been shown to be an important predictor which can influence the choice process (Gidlöf *et al.*, 2017).

Within this context, a large part of past research (Ducrot, 2015; Egnell, 2018; Galan, 2020) has been dedicated to assessing and comparing FOPLs performance on one element of the *understanding* – the *objective* one - a construct that clarifies whether the "*meaning the consumer has attached to the FOPL is compatible with the meaning that the sender of the FOPL intended to communicate*". In this respect, different authors, such as Mèjean (2013), Ducrot (2015), Julia (2015; 2017), Egnell (2018; 2019); Talati (2017; 2019), showed that Summary labels are able to gain customers' attention, support them in correctly ranking products' nutritional quality and choosing the healthiest alternative, and encourage producers to reformulate their food products (Julia & Hercberg, 2017).

On the contrary, limited effort has been dedicated to *subjective understanding*, which measures what consumers derive from the perceived label information, "*the extent to which consumers believe they have understood*" the communication in a relevant way, and how they use this information for their decision-making processes.

The objective of this work is to contribute to the current research with a perspective on how different types of FOPLs perform in order to support consumers toward healthier and more informed food choices.

The first part of the thesis aims at covering an area overlooked by the past literature, by analyzing FOPL effects on *subjective understanding* and *liking*, as consumers' responses to FOPL exposure. Evidences suggests that Nutrient-Specific labels are more supportive to consumers on *subjective understanding* and *liking* when taking an informed food decision, a result stable across different socio-demo-cultural contexts, and opposite to the evidences collected for *objective understanding*.

The second part of the dissertation then introduces a theoretical model of food decision-making, an alternative to mainstream approaches, as an attempt to overcome the non-converging results of *subjective* and *objective understanding* highlighted in the first part. The proposed framework could be used, in fact, to benchmark consumers' reaction to FOPLs in different market conditions and offers an alternative to Grunert & Wills (2007) one.

In light of this background, this thesis is structured as follows:

- Chapter 1 describes the different types of FOPL present in the market, provides an overview of the existing literature, highlights the interplay of policy development and FOPL research, and define the research focus
- Chapter 2, examines consumers' internal reactions in some fundamental steps of consumer decision-making in food –*subjective understanding* and *liking* – to different FOPLs, while benchmarking their preferences and effectiveness in Italy, a country where FOPL should still be widely adopted.
- Chapter 3 explores the performance of different FOPLs - on *subjective understanding* and *liking* - across countries with different socio-cultural contexts, the position of the Country's Governmental Bodies, percentage of penetration of overweight and obesity in the population, and the volume of the FOPL-related public debate .
- Chapter 4 introduces the Front-of-Pack Acceptance Model (FOPAM), and utilize it to compare the effectiveness of different FOPLs in supporting consumers in their decision-making toward more informed and healthier food.

- Chapter 5 concludes the work, explores the limitation of the thesis and proposes future research avenues.

This research aims then at contributing to the current effort of understanding how different systems of Front-of-Pack nutritional Labels affect consumers' decision-making processes toward healthier and more informed food choices, also as input for managers in the industry and for the ongoing policy-making discussions at the EU level.

It integrates the existing knowledge by (a) analyzing some under-researched steps in food decision-making, such as consumers' *subjective understanding* and the *liking*, and (b) proposing the *front-of-pack acceptance model (FOPAM)*, alternative to the current mainstream theoretical framework. It also shows how FOPAM could be utilized to assess the formation of consumers' attitudes and behavioral intentions related to FOPL utilization, benchmark the relative performance of different FOPL in different market settings, and help to overcome the duality of the extant literature on the two major non-converging streams of *objective* vs. *subjective understanding*

References

Becker, M. W., Bello, N. M., Sundar, R. P., Peltier, C., & Bix, L. (2015). Front-of-pack labels enhance attention to nutrition information in novel and commercial brands. *Food Policy* 56, 76–86.

Bettman, J. R. (1979). Information processing theory of consumer choice. *Addison-Wesley* Pub. Co.

Bettman, J. R., Luce, M. F., & Payne, J. W. (1998). Constructive consumer choice processes. *Journal of consumer research*, 25(3), 187-217.

Cox, G. E., & Shiffrin, R. M. (2017). A dynamic approach to recognition memory. *Psychological Review*, 124(6), 795.

DeJoy, D. (1991). A Revised Model of the Warnings Process Derived from Value-Expectancy Theory. *Human Factors Society 22nd Annual Meeting. CA Human Factors Society.* Santa Monica

Ducrot, P., Méjean, C., Julia, C., Kesse-Guyot, E., Touvier, M., Fezeu, L. K., Hercberg, S., & Péneau, S. (2015). Objective Understanding of Front-of-Package Nutrition Labels among Nutritionally At-Risk Individuals. *Nutrients*, 7(8), 7106–7125. https://doi.org/10.3390/nu7085325

Ducrot, P., Méjean, C., Julia, C., Kesse-Guyot, E., Touvier, M., Fezeu, L. K.,Péneau, S. (2015). Objective Understanding of Front-of-Package Nutrition Labels among Nutritionally At-Risk Individuals. *Nutrients*, 7(8):7106-7125

Eagly AH, Chaiken S (1993) The psychology of attitudes. *Harcourt Brace College Publishers*, Fort Worth, TX

Egnell M, Ducrot P, Touvier M, Allès B, Hercberg S, Kesse-Guyot E (2018) Objective understanding of Nutri-Score Front-Of-Package nutrition label according to individual characteristics of subjects: Comparisons with other format labels. *PLoS ONE* 13(8): e0202095. https://doi.org/10.1371/journal.pone.0202095

Egnell, M., Talati, Z., Hercberg, S., Pettigrew, S., & Julia, C. (2018). Objective Understanding of Front-of-Package Nutrition Labels: An International Comparative Experimental Study across 12 Countries. *Nutrients*, 10(10), 1542. https://doi.org/10.3390/nu10101542

Egnell, M., Talati, Z., Pettigrew, S., Galan, P., Hercberg, S., & Julia, C. (2019). Comparison of front-of-pack labels to help German consumers understand the nutritional quality of food products. Color-coded labels outperform all other systems. *Ernahr. Umsch*, 66, 76-84

Egnell, M., Talati, Z., Gombaud, M., Galan, P., Hercberg, S., & Julia, C. (2019). Consumers' Responses to Front-of-Pack Nutrition Labelling: Results from a Sample from The Netherlands. *Nutrients*, 11(8).

Findling, M. T. G., Werth, P. M., Musicus, A. A., Bragg, M. A., Graham, D. J., Elbel, B., & Roberto, C. A. (2018). Comparing five front-of-pack nutrition labels' influence on consumers' perceptions and purchase intentions. *Preventive medicine*, 106, 114-121.

Galan, P., Egnell, M., Salas-Salvadó, J., Babio, N., Pettigrew, S., Hercberg, S., & Julia, C. (2020). Understanding of different front-of-package labels by the Spanish population: Results of a comparative study. Comprensión de diferentes etiquetados frontales de los envases en población española: resultados de un estudio comparativo. *Endocrinologia, diabetes y nutricion*, 67(2), 122–129. https://doi.org/10.1016/j.endinu.2019.03.013

Gidlöf, K., Anikin, A., Lingonblad, M., & Wallin, A. (2017). Looking is buying. How visual attention and choice are affected by consumer preferences and properties of the supermarket shelf. *Appetite*, 116, 29-38.

Grunert, K. G., & Wills, J. M. (2007). A review of European research on consumer response to nutrition information on food labels. *Journal of public health*, 15(5), 385-399.

Hawley, K., Roberto, C., Bragg, M., Liu, P., Schwartz, M., & Brownell, K. (2013). The science on front-of-package food labels. *Public Health Nutrition*, 16(3):430-439.

Julia, C., Kesse-Guyot, E., Ducrot, P., Péneau, S., Touvier, M., Méjean, C., & Hercberg, S. (2015). Performance of a five category front-of-pack labelling system - the 5-colour nutrition label - to differentiate nutritional quality of breakfast cereals in France. *BMC Public Health*, 15:179.

Julia, C., & Hercberg, S. (2017). Nutri-Score: Evidence of the effectiveness of the French front-of-pack nutrition label. *Ernahrungs Umschau*, 64(12), 181-187.

Julia, C., Péneau, S., Buscail, C., Gonzalez, R., Touvier, M., Hercberg, S., & Kesse-Guyot, E. (2017). Perception of different formats of front-of-pack nutrition labels according to sociodemographic, lifestyle and dietary factors in a French population: Cross-sectional study among the NutriNet-Santé cohort participants. *BMJ open*, 7(6), e016108.

Kanter, R., Vanderlee, L., & Vandevijvere, S. (2018). Front-of-package nutrition labelling policy: global progress and future directions", *Public Health Nutrition*, 21(8), 1399–1408.

McGuire WJ (1985) Attitudes and attitude change. In: Lindzey G, Aronson E (eds) The handbook of social psychology, Vol. 2, 3rd edn. *Random House*, New York, pp 233–346

Mejean, C., Macouillard, P., Peneau, S., Hercberg, S., & Castetbon, K. (2013). Perception of front-of-pack labels according to social characteristics, nutritional knowledge and food purchasing habits. *Public Health Nutrition*, 16(3):392-402.

Nelson, A. B., & Shiffrin, R. M. (2013). The co-evolution of knowledge and event memory. *Psychological Review*, 120(2), 356.

Peter JP, Olson JC, Grunert KG (1999) Consumer behaviour and marketing strategy. *McGraw-Hill*, Maidenhead

Petty RE, Cacioppo JT (1981) Attitudes and persuasion: classic and contemporary approaches. *Brown*, Dubuque, IO

Solomon M, Bamossy G, Askegaard S, Hogg MK (2006) Consumer behaviour, a European perspective, 3rd edn. *Prentice Hall*, Harlow

Talati, Z., Norman, R., Pettigrew, S., Neal, B., Kelly, B., Dixon, H., Shilton, T. (2017). The impact of interpretive and reductive front-of-pack labels on food choice and willingness to pay. *International Journal Of Behavioral Nutrition And Physical Activity*, 14.

Talati, Z., Egnell, M., Hercberg, S., Julia, C., & Pettigrew, S. (2019). Consumers' Perceptions of Five Front-of-Package Nutrition Labels: An Experimental Study Across 12 Countries. *Nutrients*, 11(8).

1. Chapter 1 – An overview of Front-of-Pack nutritional Labels (FOPL)

The Chapter includes parts of the paper "Uncovering the Effect of European Policy-Making Initiatives in Addressing Nutrition-Related Issues: A Systematic Literature Review and Bibliometric Analysis on Front-of-Pack Labels"[5], published in Nutrients 2022, 14, 3423, under the Creative Commons Attribution (CC BY) license. https://doi.org/10.3390/nu14163423

1.1. Introduction

The last decades have been marked by the introduction of *Front-of-Pack nutritional labels* (hereinafter as FOPL) as an institutional corrective action against obesity and nutrition-related illnesses. FOPL-related policy-making initiatives issued by Regulators Bodies and by the European Union evolved over the time and led to a diversity of labels with different effects on consumers' decisions. With the aim to systematize the overall structure and evolution of the literature on FOPL, investigate the presence of a consensus on specific topics through a co-citation analysis, the evolution of the consensus and co-citation networks over the years, the potential research gaps, and the implications that the research might have on different stakeholders, the chapter reports the results of a bibliometric and co-citation analyses, and a systematic literature review involving 170 papers, analysed according to three relevant timespans, from 1989, date of the first FOPL introduction, to 2020. The evidences deriving from extant research allow to define a set of empirically validated knowledge from which to draw ideas and implications for regulatory policies and market from different perspectives, and assessed according to the objectives that FOPLs should achieve.

Following an overview of the regulatory context of reference, the chapter provides a description of the various FOPL systems, of the studies and reference theories on the effects of FOPLs in the formation and change of consumer attitude and behavior, and of the interplay of policies development and FOPL research.

Keywords: Front-of-Pack Label; Food Policy; Nutri-Score; NutrInform Battery; Multiple Traffic Light; Bibliometric Analysis; Co-citation Networks

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1.2. FOPLs history, type, status of policy and market practices

World Health Organization (WHO) highlights that the promotion of nutrition and health benefits is becoming a crucial aspect due to the growth of malnutrition-related issues (WHO, 2020). Unbalanced dietary habits are the main factor responsible for non-communicable diseases (NCD), overweight and obesity, which are increasingly becoming a serious risk for consumers, oftentimes leading to other more serious illnesses that can be prevented by implementing measures at the individual, social and governmental levels (WHO, 2020).

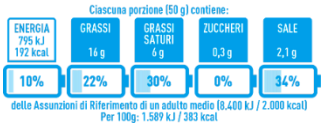
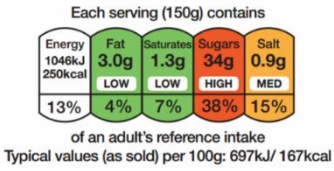
Among the tools adopted by the food industry and policy-makers, packaging could intensely contribute to changing consumers' unhealthy habits, nudge them towards salutary choices through informative cues and prevent diseases. However, over the years, the well-known and widespread back-of-pack labels (BoPL) led individuals to a lack of awareness about food features because of the perceived complexity and inaccessibility of such tools (Storksdieck Gennant Bonsmann *et al.*, 2020; Goiana-da Silva *et al.*, 2019).

To this end, governments and public institutions have intervened with the aim of encouraging and nudging consumers towards healthier choices (Barreiro-Hurlé *et al.*, 2010). As a consequence, the main countermeasures activated in the EU, the front-of-pack labels are those tools conceived to provide individuals with the details of the nutritional characteristics of products and improve the diet by increasing the consumption of healthier products (Levy *et al.*, 1998)). These tools have been conceived to raise consumers' attention to the nutritional aspects of food products as they are positioned at the front of the package (Elshiewy & Botzug, 2018). The FOPL have also been recommended for its efficacy by WHO and is considered a cost-effective tool that would benefit European public health.

However, over the years, the absence of a standardized and univocal regulation and the implicit diversity of European states has led to a variety of FOPL. In a recent attempt to systematize the presence of FOPL in Europe, the EU Commission (EU Commission, 2021) proposed a framework to interpret the existing categories and differences of such labels (Table 1). More precisely, two broad categories have been identified: (i) *Nutrient-Specific labels*, which enlighten consumers on the nutrients of products and (ii) *Summary labels*, that provide a concise overall assessment of the product through letters, colours or numbers. Among the Nutrient-Specific labels, examples are the NutrInform Battery (NiB) and Multiple Traffic

Lights (MTL), while for Summary labels examples in the European context are the Keyhole logo and the Nutri-Score (NS).

Table 1. – Adapted from EU Taxonomy and example of Front-of-Pack-Labels (EU Commission, 2021).

Taxonomy		Examples
Nutrient-Specific Labels: FOPL that provide detailed information about certain nutrients (fat, saturates, sugars, salt, and energy value) with an objective description of the quantities contained in the food	• **Numerical Labels**: non-interpretative (non-evaluative) labels, providing numerical information on the content of four nutrients (fat, saturates, sugars, salt) and on the energy value, as well as on how much this represents as a percentage of the daily reference intake	• **NutrInform Battery** (hereinafter as "NiB") 
	• **Colour-Coded Labels**: labels providing numerical information on the content of four nutrients (fat, saturates, sugars, salt) and on the energy value, as well as on how much this represents as a percentage of the daily reference intake. Colours are used to classify those nutrients as "low" (green), "medium" (amber) or "high" (red)	• **Multiple Traffic Light** (hereinafter as "MTL") 
Summary Labels: FOPL that provide a synthetic assessment of the product's overall nutritional healthfulness that is sometime the result of an algorithmic computation	• **Endorsement Logos**: labels providing a synthetic appreciation of a product's overall nutritional value through a positive (endorsement) logo that is applied only to foods that comply with nutritional criteria	• **Keyhole logo**
	• **Graded Indicators**: labels providing a synthetic appreciation of a product's overall nutritional value through a "graded indicator" that provides graded information on the nutritional quality of foods that is applied on all food products	• **Nutri-Score** (hereinafter as "NS") 

Below is a description of some of the most important FOPL within each category.

1.2.1. Nutrient-Specific labels

Nutrient-Specific systems include those labels that summarize the nutritional information of the nutrients present within the product including qualifying and disqualifying elements. In this macro-category there can be labels that report exclusively nutritional information, such as the Reference Intake (RI), or even labels that enrich this nutritional information through the use of colors or symbols that can somehow facilitate interpretation by of the consumer of the information presented. To this second category belong the Multiple Traffic Light (MTL), which

integrates information through the use of traffic light colors, and the NutrInform Battery , which enriches the information through a battery symbol.

Reference Intake

The Guideline Daily Amount (GDA) is a nutrition label developed in 1998 by UK institutions as a result of a collaboration between the Government, the food industry and some consumer organizations under the supervision of the Food Distribution Institute. The GDA provides guidelines to help consumers translate the ingredient list on the product label into useful dietary information , through the quantitative value of calories, fat, saturated fatty acids, sugars and sodium / salt, both in total. and as a percentage (per portion) with respect to the reference daily intake for an average adult. In 2009, the European Food Safety Authority (EFSA) published a scientific opinion on the Reference Intake (RI) for energy and key nutrients in Europe, which broadly corresponded to those set by the European Union. United Kingdom. Pursuant to Regulation 1169/2011, which incorporated the RI, the GDA was replaced by Reference Intake, maintaining the same principles. Since then, the RI / GDA label has become common in the rest of Europe and has been voluntarily adopted by prepackaged food and beverage manufacturers in several EU countries.

Multiple Traffic Light

The so-called Multiple Traffic Light (MTL) or Color-Coded % RI systems are mostly present in the United Kingdom, and also in the past in Ecuador, South Korea, and Spain and Portugal in private retailers. These labels are also called *nutrient-based evaluative* because in addition to the amount of calories, total fat, saturated fat, sugar and salt present in the portion of food or drink, they combine the color green, amber and red. Color coding indicates high (red), medium (amber) and low (green) levels of negative nutrients. Like the RI, the MTL can be adopted for all categories of prepackaged products without distinction. In particular, in the UK the MTL nutrition labeling scheme was introduced on a voluntary basis in 2013 and was recommended by the UK Food Standards Agency and the UK Department of Health.

NutrInform Battery

The NutrInform Battery is an Italian proposal by FOPL nutrient based developed starting from February 2018 by a working group that involved four Ministries (Health, Agricultural Policies, Foreign Policies and Economic Development), the ISS (Istituto Superiore di Sanità, the official

scientific body of the Minister of Health), CREA (Council for Research in Agriculture and Analysis of Agricultural Economics - Food and Nutrition Center), some representatives of the National Consumer Council and all associations of the food supply chain, from primary production to distribution. The fundamental purposes of the new scheme are to adequately inform the consumer about the energy content of the products and the quantity of the main nutrients per serving and not for the generic measure of 100 grams; to ensure that information is used by consumers to gain greater nutritional awareness in order to eat a healthy, varied and balanced diet every day; to comply with all European standards under the various consumer information regulations. After a series of research and qualitative tests, the working group developed the NutrInform Battery label , a new FOPL information system, but enriched by a visual component, the battery symbol. The presence of graphics therefore allows the NutrInform Battery to be defined as an enriched nutritional information system, distinguishing itself from purely information systems, such as the Reference Intake (RI).

The battery is an internationally recognized symbol, used in the case of NutrInform Battery to show at a glance the energy level and the main nutrients contained in a portion of the product compared to the reference intakes of an average adult. The concept of replenishment versus the empty space still available for other foods allows consumers to choose and eat foods while taking into account the overall diet. Therefore, the presence of the battery aims to help the consumer to develop their daily diet by balancing the food products chosen and considering the fact that these must not cause the battery charge level to be exceeded for each nutrient.

1.2.2. Summary labels

The term *Summary system* indicates all those interpretative labels that provide a generic and synthetic evaluation of the healthiness of the product, examining several nutrients not explicitly mentioned. They almost always use infographics in order to easily communicate the level of healthiness, evaluated through a scoring system. Therefore, the final judgment is on the product as a whole.

Keyhole

Keyhole is a Swedish registered trademark owned by the National Food Administration and its symbol has been used in the Swedish market for about thirty years. Denmark and Norway

implemented it in 2009, followed by Iceland in 2014[6]. The *Keyhole* label is only applied to products that meet certain requirements according to the dietary guidelines of these countries: less salt, sugar and saturated fat, and more fiber. This system considers components such as artificial sweeteners, total sugars and added sugars in the calculation. The goal is to encourage consumers to make healthier food choices.

Healthier Choices

Starting from the labels present across the continent, *Healthier Choices* from Singapore (1998) provides a product evaluation resulting from a calculation based on the percentage of the limit values of total fat, saturated and trans fat, sodium, sugars and calcium on more than 60 product sub-categories. Also in Thailand (2016), the Healthier Choices gives a final evaluation calculated on the basis of information per serving and per 100g / ml on sodium, sugars, calories, total and saturated fat, calcium, protein and iron for drinks, sauces, condiments, snacks and ready meals. The analysis per 100g / ml is also carried out in Brunei (2017), which however analyzes, to provide a final evaluation, total, saturated fats, sodium, sugars and calcium. Therefore, each model adopts its own method for calculating the algorithm which in the end gives an overall judgment represented by a symbol that certifies the healthiness of the product.

Choices Logo

The label present in the past in Netherlands (2006) and the Czech Republic (2011), is the result of the participation of various stakeholders from the industrial and scientific research sectors and aims to support the national programs that promote healthier food choices through product reformulation and consumer education. National bodies individually regulate program implementation and industry participation.

Warning labels

Warning labels (WL) provide a negative or positive evaluation of products considering only one nutrient contained in the product. The approach tends to be of a disqualifying type, as they evaluate the quantity of a single nutrient considered negative. In the case of a negative tone of voice , they often use forms linked to the semantic field of danger. Finland was the first country, in the early 1990s, to introduce a real warning label for excessive sodium content in some food

[6] http://norden.diva-portal.org/smash/get/diva2:700822/FULLTEXT01.pdf; https://www.livsmedelsverket.se/en/food-and-content/labelling/nyckelhalet; https://www.helsenorge.no/en/kosthold-og-ernaring/keyhole-healthy-food/

products. Currently these labels are present, among others, in Chile (2016), Israel (2020) and Peru (2019), as mandatory by law. The Warning Labels are characterized by the color black or red with texts that indicate for which nutrient the value is high and therefore consumption constitutes a real health risk.

In particular, the Chilean Warning Labels were introduced in 2016 as a mandatory scheme, characterized by a black octagon, attributable to the stop sign, and an inscription inside it specifying that the product is "high in", followed by the critical reference nutrient, i.e., calories, saturated fat, sodium or sugar. Each product can have one or more octagons. In addition to encouraging the consumption of those products with low amounts of critical nutrients, the purpose of the warning labels is to encourage producers to reformulate those products with high values of critical nutrients. Other South American countries, such as Mexico, Brazil, Peru and Uruguay, as well as Canada and Israel have developed or are developing "warning" schemes.

SENS

The FOP *SENS* label was also developed in France (2015) as an evolved version of the SAIN system, LIM which classifies foods into four classes based on a nutrient density score called "SAIN" (healthy) , a score of nutrients to be limited called "LIM" (to be limited) and a primary threshold for each score. Each product is marked with a colored triangle: the color and size of the figure on the label indicate the recommended consumption frequency: often, sometimes, moderately, occasionally (Darmon, Sondey, Azais-Braesco, & Maillo, 2018). Also in this case a general and summary evaluation of the product is provided and not with specific reference to the individual nutrients. Each labeling system considers different nutrients and measurements.

Health Star Rating System

This label introduced in 2014 in Australia and New Zealand includes within the evaluation, in addition to calories, saturated fats, sodium, sugars and proteins, also fiber, fruit and vegetables providing a judgment on standard dose of 100g / ml. In this case there are no percentage ratings based on the reference intakes of an average adult, as in the RI, but a low to high scale is used for each of the critical nutrients. In addition, an overall assessment of the product is provided through a 5 - star system calculated using an algorithm that differs in relation to the category of product analyzed.

Nutri-Score

The *Nutri-Score*, currently present in France (2017), Belgium (2019), Switzerland (2019) Germany (2020), , Luxembourg (2020), consists of a 5-color label and linked letters that with each letter / color combination inform consumers about the nutritional quality of the products. The green letter A indicates best outcome of the nutritional algorithm as product to be taken on nutritional basis, while the red letter E indicates the less favorable products in terms of composition and nutritional quality. The letter that classifies the product is larger than the others on the label . The *disqualifying nutrients* are analyzed: calories, saturated fats, sugars, sodium and proteins, balancing with the presence of *qualifying nutrients* also including fiber, fruit and vegetables per 100g / ml. The final calculation is a score between -15 and +40 deriving from an algorithm that assigns positive points to the nutrients that disqualify the product and negative points to the qualifying ones. The label does not apply to all food categories in the same way: for cheeses and soft drinks the classification is changed. Furthermore, products such as fruits, fresh vegetables and fresh fish are not involved in the FOPL process, and similarly wine is not. Aspects such as frequency of product intake, recommended quantity, ratio with daily requirement are not traced in the algorithm, but an evaluation of the product based exclusively on the nutrients present is obtained.

Endorsement logo labels

Endorsement logos are labels that provide a positive evaluation by considering multiple nutritional values within a product, using both a qualifying and disqualifying evaluation approach, providing a generic evaluation of the product. This category includes FOPLs from private initiatives, such as Non-Governmental Organizations.

* * *

Currently, FOPL systems on food and beverages, albeit with a variety of formats and application rules, are present in more than 40 countries around the world. Although most countries have decided to let the adoption of nutrition labels take place on a voluntary basis, some countries have made them mandatory. Overall, there is a tendency to homogenize laws and regulations between geographically neighboring countries or rather belonging to the same region, which for this reason also share some cultural traits, although there are elements of specificity dictated by the market structures differentiated by the particularities of each country.

A visualizing symbol of all the FOP labels listed above is included in Figure 1[7], and a summary timeline of main events up to 2019 is represented in Table 2.

Figure 1: Example of Front-of-Pack nutritional labels

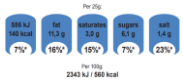
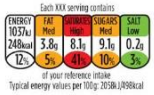
Front-of-Pack Label	Symbol
Reference Intake	
Multiple Traffic Light	
NutrInform Battery	
Health Star Rating	
Nutri-Score	
SENS	
Healthier Choices	
KeyHole	
Choices Logo	
Warning label	

Table 2: Timeline of Front-of-Package (FOP) nutrition labeling globally, Source: (Kanter , Vanderlee, & Vandevijvere, 2018)

Date	Country	What
1989	Sweden	Establish criteria for and introduces the **Keyhole Logo**
1993	Finland	Implements mandatory display of **Warning Labels** on foods high in salt
1998	Singapore	Implements the **Healthier Choice** symbol

[7] Images retrieved from: Reference Intake https://referenceintakes.eu/understanding-label.html; Multiple Traffic Light (MTL) https://ec.europa.eu/food/sites/food/files/safety/docs/labelling-nutrition_fop-report-2020-207_en.pdf ; https://pdfs.semanticscholar.org/6dc0/9d8ecca3abd2a42d9ff4abf09ac68e5715b7.pdf; NutrInform Battery authorized use by Federalimentare; Health Star Rating http://www.healthstarrating.gov.au/internet/healthstarrating/publishing.nsf/Content/How-to-use-health-stars; Nutri-Score https://www.researchgate.net/figure/FOP-label-tested-SENS-a-Nutri-Score-b-Nutri-Repere-c-Nutri-Couleurs-d_fig2_340377483; SENS https://www.researchgate.net/figure/FOP-label-tested-SENS-a-Nutri-Score-b-Nutri-Repere-c-Nutri-Couleurs-d_fig2_340377483; Healthier Choice (Singapore: https://www.healthhub.sg/livehealthy/211/make_healthier_choice ; Tailandia: http://healthierlogo.com/wp-content/uploads/2017/10/%E0%B8%A0%E0%B8%B2%E0%B8%A9%E0%B8%B2%E0%B8%AD%E0%B8%B1%E0%B8%87%E0%B8%81%E0%B8%A4%E0%B8%A9_%E0%B8%AB%E0%B8%99%E0%B8%B1%E0%B8%87%E0%B8%AA%E0%B8%B7%E0%B8%AD%E0%B8%97%E0%B8%B2%E0%B8%87%E0%B9%80%E0%B8%A5%E0%B8%B7%E0%B8%AD%E0%B8%81%E0%B8%AA%E0%B8%B8%E0%B8%82%E0%B8%A0%E0%B8%B2%E0%B8%9E.pdf ; Brunei: http://www.moh.gov.bn/SitePages/healthychoicelogo.aspx#:~:text=Healthier%20Choice%20Logo,of%20nutrition%2C%20obesity%20is%20preventable.); Keyhole https://ec.europa.eu/food/sites/food/files/animals/docs/comm_ahac_20180423_pres2.pdf; Healthy Choice https://www.choicesprogramme.org/; Warning Labels https://pdfs.semanticscholar.org/6dc0/9d8ecca3abd2a42d9ff4abf09ac68e5715b7.pdf

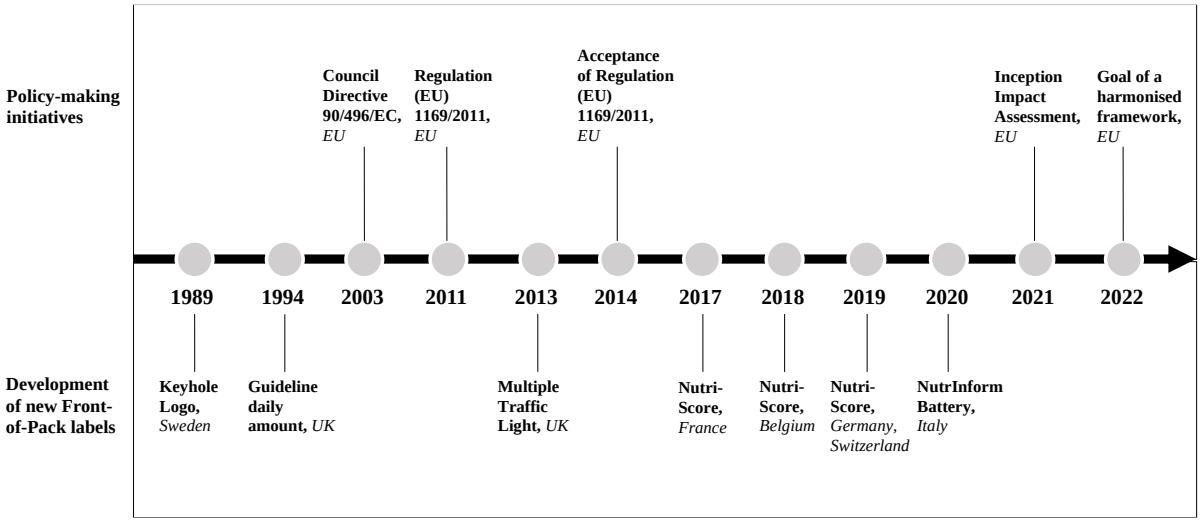
2003	Singapore	Extends the **Healthier Choice** symbol to hawkers and food-service operators
2006	The Netherlands	The firs country to introduce the **Choices** logo
2007	Belgium	Introduces the **Choices Programme** logo
	Thailand	Makes **GDA** and **Warning Labels** mandatory for five categories of snack foods, and introduces a voluntary logo for products with 25% less salt, sugar and saturated fat
2008	Poland	Introduces the **Choices Programme** logo
2009	Sweden/ Denmark/ Norway	Launch a common voluntary **Keyhole logo** to identify healthy foods
	Fiji/ Salomon Islands	Introduces on-shelf labels for food high in fat
2011	EU	EU regulation 1169/2011 allows EU Member States plus Iceland, Norway, Liechtenstein and Switzerland to develop voluntary FOP guidelines which allow GDA or voluntary traffic light styles
	South Korea	Implements voluntary **Traffic Light** labelling on children's food products for total sugars, fat, saturated fat and sodium
	Czech republic	Introduces the **Choices Programme** logo
2012	Chile	Approves the Chilean Law of Food Labeling and Advertising to require **Warning Labels** for products high in salt, sugar, fat and energy (calories)
2013	UK	Introduce the voluntary **Traffic Light** labelling for energy, fat, saturated fat and sugar
	Ecuador	Introduces mandatory **Traffic Light** labelling for sugar, fat and sodium
	EU	Approves the **Choices Programme** logo in all countries
	Lithuania/ Iceland	Sign the agreement to join the **Keyhole** programme
	Indonesia	Proposes mandatory **Warning Labels** on foods high in sugar, salt and fat
2014	Australia/ New Zealand	Introduces the voluntary **Health Star Ratings** system
2015	Chile	Approves the regulatory norms required for implementation of the Chilean Law of Food Labelling and Advertising
	Sweden/ Denmark/ Norway/ Iceland/ Lithuania	Introduces stricter requirements for the **Keyhole** logo
	Singapore	Launches a refreshed **Healthier Choice** symbol based on revised nutrient guidelines
	Peru	Approves technical parameters for labelling sugar sodium, saturated fat and trans-fat
2016	Chile	Mandatory **Warning Labels** come into effect for products high in salt, sugar, fat and energy (calories)
	Thailand	Introduces a voluntary **Healthier Choices** logo
	Israel	Proposes **Warning Labels** for sodium, total sugar, and saturated fat
	Canada	Holds consultation for proposed **Warning Labels** for sugar, saturated fat and sodium
2017	Brunei	Introduces a voluntary **Healthier Choice** symbol, based on the model from Singapore
	Malaysia	Introduces a voluntary **Healthier Choice** logo
	France	Implements the voluntary **Nutri-Score** labelling system
	Peru	Publishes implementation manual on **Warning Labels** for comment
2018	Chile	Plans to implement the second phase of more restrictive nutrient limits for mandatory **Warning labels**
	Israel	Proposed implementation date for **Warning Labels**
2019	Australia/ New Zealand	Plan to launch results from forma review and consultation on the **Health Star Ratings** system
	Chile	Plans to implement the final phase of more restrictive nutrient limits for mandatory **Warning Labels**

1.2.3. Regulation and FOPL development

The aforementioned labels are the result of a sequence of policy-making and regulatory initiatives, started in 1990s, that led European countries and Member States to activate institutional corrective and preventive actions against obesity and design their proposals (See

Figure 2) to address nutrition-related issues. Indeed, the Council Directive 90/496/EC (EC, 1990) regulation suggested for all EU Member States the adoption of labelling systems on food products to be delivered to the final consumer and established the information that a label must contains (such as energy consumption and nutrients such as protein, carbohydrates, fat, fibres, sodium, vitamins, and minerals). A policy-making initiative aimed at aligning the European Union to the best practices available outside the Union in that period in terms of food information provided to consumers.

Figure 2. – Evolution of policy-making initiatives and FOPL



Indeed, the first FOPL, known as Keyhole logo, appeared in 1989 in Sweden (van der Bend & Lissner, 2019), with the aim to prompt individuals to make healthy food choices easier: all the products with a Keyhole logo associated, represent a healthier option (Jones *et al.*, 2019).

In 2011, the new EU Regulation 1169/2011 allowed Member States and companies to provide nutrition declaration on the FOPL (EU Commission, 2011). In 2014, the application of such regulation became mandatory, enforcing the usage of nutrition declaration on pre-packaged foods, about the nutritive values in the food. In addition, in 2020, the European Commission modified the previous EU Regulation 1169/2011 (EU Commission, 2011) – focused on the presentation guidelines of nutritional details to consumers - by publishing a first impact assessment on nutrition labelling and nutrient profiles on the front of pack and out-lining the initial analysis regarding issues, policy objectives, different solutions and likely impacts (EU Commission, 2020). As a result, a set of different proposal has been outlined over the years as effects of the policies implemented and approved by the Member States. In 2013 emerged

the Multiple Traffic Light in the United Kingdom and the Nutri-Score in 2017 in France and in other Member States in the following years: Belgium (2018), Germany (2019), Switzerland (2019) and Luxembourg (2020). In addition, in 2020 the Italian Government proposed the NutrInform Battery System.

With the more recent "*Farm-to-Fork*" strategy, the EU initiated an attempt to harmonize FOPL, while, at the same time, scholars started integrating the concept of FOPL harmonization in their work (EU Commission, 2021). Additionally, within the Inception Impact Assessment, the EU even declared the goal of finding a unifying solution after assessing the differential performance of multiple FOPLs, such as the Nutri-Score, the NutrInform Battery, and the Keyhole.

Over the years, the policy-making initiatives and FOPL implementation evolved into a mutual relationship, and the research testifies to this everlasting exchange, highlighting the reciprocal effects of both. Indeed, extant literature welcomed the proposals of European States researching the effectiveness of the resulting FOPL and their effects on consumers' attitudes, choices, and behaviours across countries over the years (Hersey *et al.*, 2013; Ducrot *et al.*, 2015; Egnell *et al.*, 2018; Talati *et al.*, 2019).

In this context, the theoretical framework of Grunert and Wills (Grunert & Wills, 2007), has been one of the most recurrent in the literature (Hersey *et al.*, 2013; Ducrot *et al.*, 2015, Egnell *et al.*, 2018; Aschermann-Witzel *et al.*, 2013; Talati *et al.*, 2019; Croker *et al.*, 2020).

1.3. Effect of FOPL on consumers along the decision-making process – The reference model

Several studies on FOPL, utilized in the past the conceptual framework of Grunert & Wills (2007) to analyze FOPLs' performances in different socio-demo contexts.In their theoretical framework, Grunert & Wills (2007) distinguish two types of *understanding*: objective and subjective. *Objective understanding* happens when the meaning the consumer attaches to the information on the label represents what is intended to be conveyed by the sender; *subjective understanding* is defined as the meaning individually attributed to the information on the label by the consumer. Drawing on this framework, many authors attained opposite results. After the release of *Summary labels*, several studies discussed the benefits of the graded indicators (e.g., Nutri-Score) under the investigative lens of objective understanding (Ducrot *et al.*, 2015; Egnell

et al., 2018; Egnell *et al.*, 2019). For instance, some scholars observed that summary labels are more effective in conveying information, even if consumers might not fully trust them due to the absence of information related to nutritional values (Hersey *et al.*, 2013; Ducrot *et al.*, 2015; Egnell *et al.*, 2018; Talati *et al.*, 2019). Conversely, other studies, by focusing on *subjective understanding*, pointed out that nutrient-specific labels are easier for consumers to understand (de le Cruz-Gòngora *et al.*, 2017). The degree of healthiness is better understood when the nutrient-specific systems are used because the completeness and specificity of the information allow consumers to better define nutritional values (Hersey *et al.*, 2013).

However, other studies highlight the higher ease of use of colours of the summary labels (Talati *et al.*, 2019) than FOPL labels showing only numerical information (Hersey *et al.*, 2013). In addition, a study conducted by Egnell *et al.* (2018) stated that FOPL had an important influence on the understanding of the healthiness of the products, and the NS led to a higher objective understanding relative to other FOPL. Since consumers have limited processing time and need to make decisions quickly, understanding the healthiness is easier with the summary label (de le Cruz-Gòngora *et al.*, 2017). While Mejean *et al.* (2013a; 2013b) and Van Herpen *et al.* (2014) highlighted that MTL is the FOPL that reaches more consensus thanks to the detailed representation of nutritive values of the product and usage of colours, conversely, when NS labels started to emerge, Ducrot *et al.* (2015) affirmed that the label demonstrates a stronger performance in consumers without nutritional knowledge.

The current literature provides researchers with a plethora of valid and generalizable results. In this prolific field of contributions, some authors seem to converge on the same valid results; other scholars present opposite valid findings, contrasting their demonstrations. While some research streams show a comprehensive analysis of the different perspectives and the diversity of valid findings, other streams mainly refer to convergent contributions, reinforcing the centrality measures of the co-citation networks and the resulting bibliometric indicators. Additionally, many studies confirm different perceptions of product healthiness according to the observed FOPL and with different results in different countries.

This vivid and constant level of contributions lay down the foundations for understanding the multifaceted magnitude of significant effects generated by FOPL. However, previous studies did not fully investigate whether fields of common consensus and over or under-researched topics exist. Additionally, in line with the WHO Guidelines (2019), FOPL are

universal and valid tools for fighting diseases. However, the nature, type and magnitude of their effects vary according to the variable investigated, the country, and the type of FOPL observed.

With the aim to understand the structure of the extant literature on FOPL, the fields already covered by researchers and potential research gaps, in the remainder of this article we report the results of a bibliometric and co-citation analyses, and a systematic literature review involving 170 papers analysed according three timespans: Period 1 (1989-2011); Period 2 (2012-2016) and Period 3 (2017-2022). The three periods have been defined according to relevant events that marked important steps in the evolution of the policies related to FOPL. In 1989, Sweden developed its first FOPL, and in 1990, the EU issued the first regulation on nutrition labelling systems. In 2011, the European Union authorized Member States and other countries (Switzerland, Lichtenstein, Norway and Iceland) to voluntarily develop FOPLs and contribute to the evidence on the effectiveness of distinct FOPL. From this year onwards, we aim to observe the effects of this regulatory advancement. In 2017, the NS was introduced for the first time in France, and the provision on nutritional information suggested by Regulation (EU) 1169/2011 became mandatory. These events contributed to the EU policy-making environment, and the extant literature varied and registered the effects accordingly.

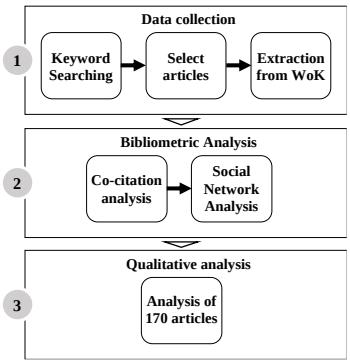
In this vein, the following part of the chapter aims to investigate the mutual effects of policies and FOPL and how the extant literature evolved accordingly over the aforementioned periods of time in terms of (i) presence of a consensus on specific topics through a co-citation analysis, (ii) the evolution of the consensus and co-citation networks over the years, (iii) the relative network indicators and (iv) potential research gaps.

1.4. Materials and methods

The present study was conducted respecting three sequential stages. In the first stage we researched articles on Web of Knowledge (WoK) to prepare the data set. In the second stage we ran a bibliometric and co-citation analysis to further analyse our data. Also, we used Social Network Analysis (SNA) to unveil the most influential authors within the network and their characteristics. In the last stage, we systematically re-viewed and qualitative analysed all the articles to investigate shared patterns, topics and assess existing gaps[8] (Figure 3).

[8] This systematic review has been carried out respecting the guideline of PRISMA and has been registered on PROSPERO

Figure 3. – Main stages of the research.



Data collection

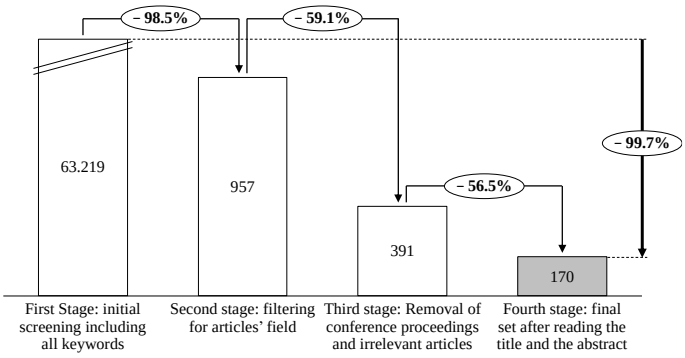
Considering the broader nature of research on FOPL, the relevant material has been scattered across various journals. In the present study, FOPL articles have been initially retrieved in 9 types of journals: (1) Nutrition Dietetics, (2) Public Environmental Occupational Health, (3) Behavioural Sciences, (4) Economics, (5) Business, (6) Communication, (7) Management, (8) Food Science Technology, (9) Computer Science Information Systems. Since the main goal of this paper was to explore and review the extant literature on FOPL with the aim to understand the effect of policy-making initiatives and fulfil potential gaps, the research was mainly conducted focusing on four types of journals. The analysis started with the definition of a query for searching only relevant documents through Web of Knowledge. Authors carried out an extensive search through the keywords "*front-of-pack nutrition label*", "*front-of-pack*", "*labelling*", "*nutritional labelling*", "*food-package*", "*front of pack*", "*food label*", "*food product*", "*nutrition*", "*Nutri-Score*", "*food marketing*", "*NutrInform Battery*", "*Keyhole*", "*nutrient specific*", "*summary labels*", "*Multiple Traffic Light*" in the title, abstract and full texts. The adopted timeframe went toward a 32-year research period from 1989 to 2022. Using the "*exact phrase*" keywords without narrowing the sources, 63.219 documents were reported.

In this perspective, the second step involved a delimitation of sources. Authors recalled only journals in the field (1) Nutrition Dietetics, (2) Public Environmental Occupational Health, (3) Behavioural Sciences and (4) Food Science Technology. This step led to 957 papers, out of which 391 were selected after removing conference proceedings.

Subsequently, after a first read of the titles and abstracts about 121 papers were excluded because considered not concordant with the purposes of the research. This phase led to the

selection of 170 articles from 85 journals, which poses the basis of the analysis. Figure 4 summarizes the steps of the article identification process.

Figure 4. – Selection of articles.



Bibliometric analysis and centrality measures

Several studies leveraged on bibliometric analysis to investigate the literature of different topics, including advertising (Kim & McMillian, 2008), strategic management (Vogel & Guttel, 2013), food labelling and policy (Latino *et al.*, 2019). However in the nutrition labelling-related fields, the bibliometric analysis, especially co-citation analysis, has not been widely used. Packer *et al.* (44) reviewed and meta-analysed the literature on FOPL based on 2-years of research. Talati *et al.* (2017) systematically reviewed the literature to assess the consumers' responses to health claims on FOPL (Ikonen *et al.*, 2020).

Considering these methodological gaps and with the aim to investigate the structure of the FOPL-related literature, a bibliometric analysis was run and, specifically, a co-citation analysis on the topics. Co-citation analysis is a common bibliometric analysis method (Ding *et al.*, 2001) and highlights when to articles are referenced at the same time in a paper (Small, 1973). The higher is the level of co-citations, the grater is the commonality between two papers (Benckendoff & Zehrer, 2013). It is a method useful to investigate the cumulative tradition, knowledge base, and intellectual structure of scientific research (Koseogolu *et al.*, 2015; Pasadeos *et al.*, 1998). However, only through a qualitative analysis and careful reading of articles is possible to have a deeper depiction about the contents of the literature (Bichteler *et al.*, 1980). To this end, a systematic review of all the articles to further investigate the contents of each article was conducted. Previous studies using a combination of co-citation and

systematic review indicated complimentary roles of the two analyses (Braam *et al.*, 1991) and after employing both methods, Ström (2002) also indicated that the combination of the two methods provided better results.

Also, a set of centrality measures has been employed to discover the role of authors within the network and their relative importance. The *betweenness centrality* has been computed to discover the times a node is connected to the shortest path between two vertices. The higher the presence of an actor in these paths, the higher the power to control communication since several links are passing through those paths. Nodes that are present on many paths are more relevant in the communication process. Similarly, the *closeness centrality* has been outlined to represent the average distance, or average shortest path, to all other vertices in the network (Bavelas et al, 1950; Beauchamp, 1965). A central actor would be close, on average, to other vertices in the network. The measure allows to evaluate if a central vertex is "close" to other nodes. The sub-components or sub-groups of networks are also called cliques (Izquerdo & Hanneman, 2006), de-facto representing co-citation clusters. Moreover, a clique is a component of a larger network where the nodes are strongly linked among them and with a few weak ties with other actors (Izquerdo & Hanneman, 2006).

At the end, the *PageRank* (Brin & Page, 1998) index has been involved to assesses the relevance of nodes in the network modelling the probability that a *random* node who starts at a random position in the network and continues following links, will connect to a vertex in the network. Another nodes-specific metric has been computed to assess the impact of authors in terms of citations. Indeed, each centrality measure has been correlated to H-Index to assess the association between the variables and what explain impact of an author.

Data analysis

The bibliometric analysis has been carried out with R (bibliometrix package) (Aria *et al.*, 2017). The analysis of the extant literature on FOPL focused on: (1) year of publication; (2) names and number of authors; (3) the type of study; (4) the analysis carried out; (5) the co-citation networks and their evolutions over the three timespan. The co-citation networks have been developed through the Louvain method (Blondel *et al.*, 2008) for community detection which aims to maximize the modularity of a subcomponent of a network. By doing so, the density of a subcomponent is higher than the overall density of the entire network, i.e., the nodes connected

in a community rely on a highest degree of connections when compared to the degree of connections with the members out of their community and the overall network.

The membership of a specific network is defined on the basis of the links that exist between one author and another, i.e., the number of times they are cited. The authors who mention each other the most belong to the same component of the network otherwise they refer to different clusters. In the remainder of the paper we will number each observed network as co-citation networks. To further observe the mutual effects of the policies on FOPL and viceversa, we investigated the evolution over the time of the literature and divided the dataset according to three timespans: (1) Period 1 (1989-2011); (2) Period 2 (2012-2016); and (3) Period (2017-2020). The results of the aforementioned section are highlighted in the "Quantitative findings" section.

After observing the quantitative results and analyzing all the articles according to the three timespan to find additional evidence emerging from the contents discussed by authors, it was discussed in the "Qualitative findings" section.

1.5. Results

1.5.1. Quantitative findings

The 170 papers analysed were collected from 85 journals. Since the timeframe goes toward 1989 to 2020, an increasing focus on the topic over the years has been noticed with two recent peaks of interest in 2019 and 2020 with an average annual growth rate equals to 14.25% and an average citation rate per year of 2,79% (Figure 5).

Of the abovementioned 170 papers, 148 were empirical studies, 3 research papers and 19 literature reviews. Across the empirical studies several methodologies has been adopted. As shown in Figure 6, the most used methodologies are ANOVA, Regression analysis, Literature Reviews and Structural Equation Modelling. Only few authors adopted mixed and qualitative methods to conduct their studies.

Figure 5. – Evolution of the literature over the time.

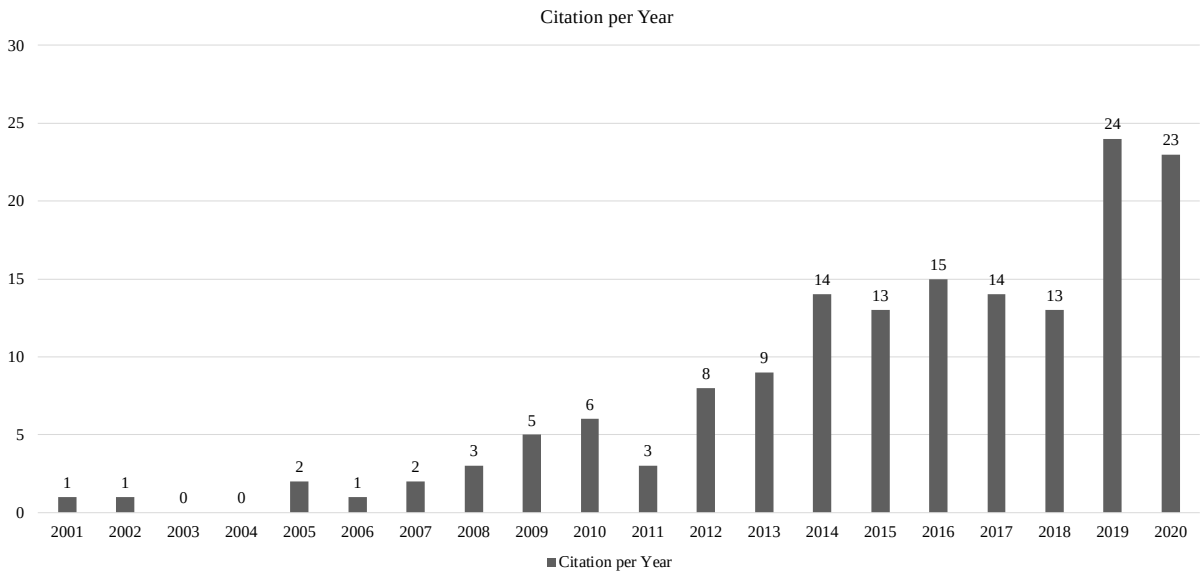
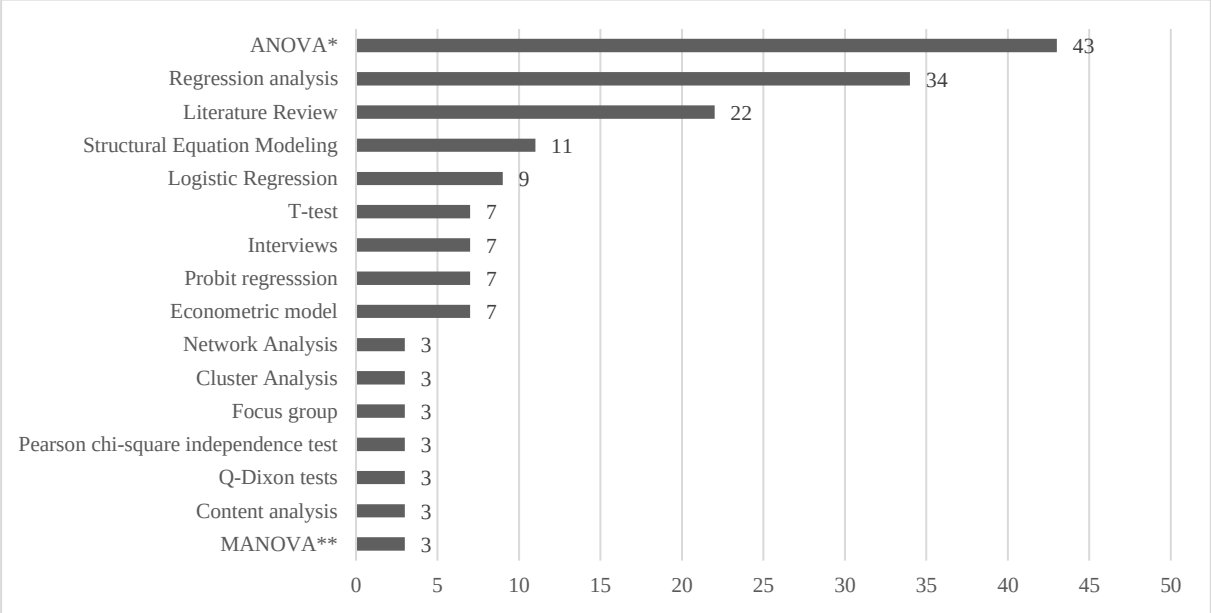


Figure 6. – Adopted methodologies and analysis approach



**ANOVA: Analysis of Variance; **MANOVA: Multivariate Analysis of Variance*

Also, the analysis involves 485 authors, with an average of 2,85 authors per paper and only 12 single-authored documents. On average each document is cited 19.14 and the total amount of references reported by all documents in the dataset equals 5234. The most cited article has been written by Drichoutis *et al.* (2005), followed by Andrews *et al.* (2011) and Barreiro-Hurlé *et al.* (2010) (see Table 3). The most relevant journals on the topic are Food policy, Journal of

Public Policy & Marketing, Nutrients and Journal of Food Products Marketing (see Figure 7). Similarly, the most cited authors are depicted in Figure 8.

Table 3. – Most cited articles.

Article	DOI	Total Citations	Average Citation per Year
DRICHOUTIS AC, 2005, EUR REV AGRIC ECON	10.1093/erae/jbi003	177	9,83
ANDREWS JC, 2011, J PUBLIC POLICY MARK	10.1509/jppm.30.2.175	121	10,08
BARREIRO-HURLE J, 2010, FOOD POLICY	10.1016/j.foodpol.2009.12.006	119	9,15
ANSELMSSON J, 2014, J PROD BRAND MANAG	10.1108/JPBM-10-2013-0414	85	9,44
DUCROT P, 2016, AM J PREV MED	10.1016/j.amepre.2015.10.020	84	12,00
ANDREWS JC, 2009, J PUBLIC POLICY MARK	10.1509/jppm.28.1.41	79	5,64
TEISL MF, 2001, AM J AGR ECON	10.1111/0002-9092.00142	79	3,59
IKONEN I, 2020, J ACAD MARK SCI	10.1007/s11747-019-00663-9	62	20,67
KIESEL K, 2013, INT J IND ORGAN	10.1016/j.ijindorg.2010.11.002	62	6,20
BECKER MW, 2015, FOOD POLICY	10.1016/j.foodpol.2015.08.001	57	7,13
HOWLETT E, 2008, J PUBLIC POLICY MARK	10.1509/jppm.27.1.83	57	3,80
BIALKOVA S, 2013, FOOD POLICY	10.1016/j.foodpol.2013.04.010	56	5,60
NEWMAN CL, 2014, J RETAIL	10.1016/j.jretai.2013.11.001	53	5,89
DUCROT P, 2015, PLOS ONE	10.1371/journal.pone.0140898	51	6,38
ELLIOTT CD, 2009, CAN J COMMUN	10.22230/cjc.2009v34n3a2220	50	3,57
TALATI Z, 2016, NUTRIENTS	10.3390/nu8120787	50	7,14
OZRETIC-DOSEN D, 2007, J BUS RES	10.1016/j.jbusres.2006.10.011	49	3,06
DRICHOUTIS AC, 2008, EUR J HEALTH ECON	10.1007/s10198-007-0077-y	48	3,20
RAHKOVSKY I, 2013, FOOD POLICY	10.1016/j.foodpol.2013.08.013	47	4,70
BARREIRO-HURLE J, 2010, J AGRIC ECON	10.1111/j.1477-9552.2010.00247.x	44	3,39

Figure 7. – The most cited sources.

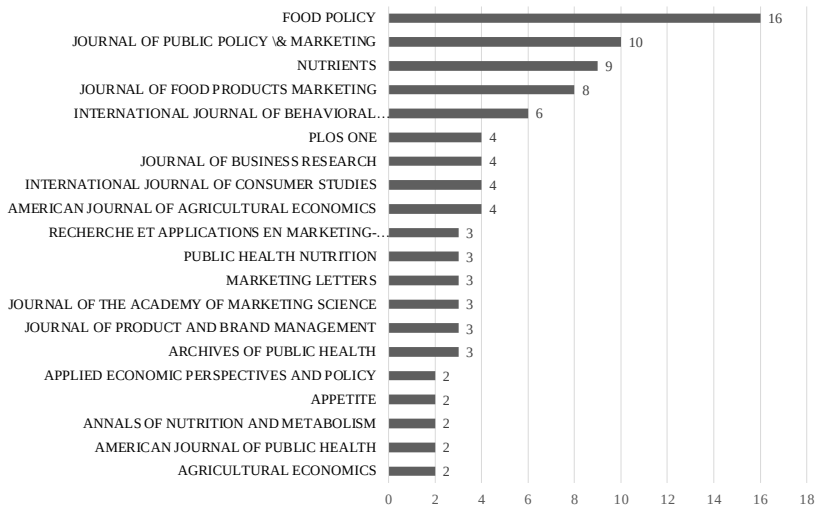
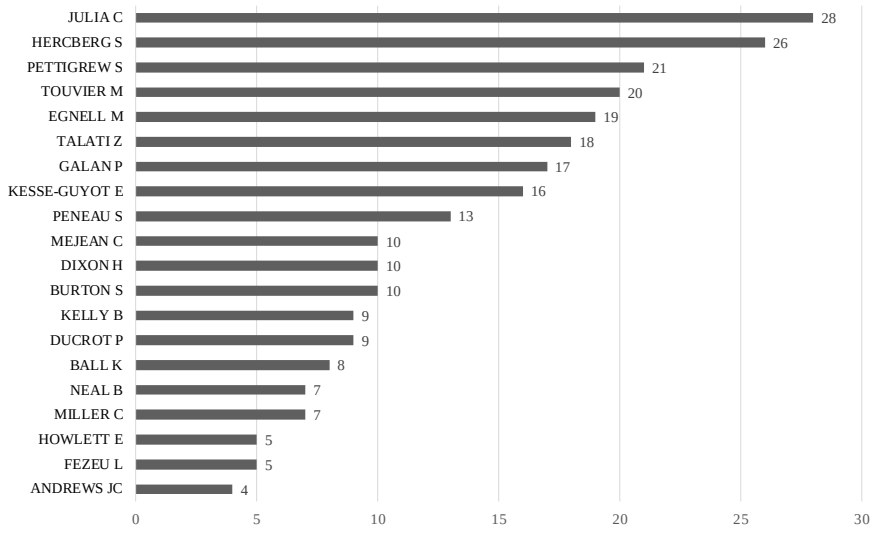


Figure 8. – The most cited articles.



The most prolific countries are USA, with 194 documents and 1115 citations, France with 155 documents and 658 citations and Australia, with 127 and 371. Similarly, the most collaborative countries are USA, France and Australia (Table 4).

Table 4. – Most prolific countries and the number of citations.

Country	Frequency	Total Citations
USA	194	1115
FRANCE	155	658
AUSTRALIA	127	371
UK	31	43
SPAIN	28	163
GERMANY	21	54
CANADA	20	132
ITALY	20	45
CHINA	17	50
NETHERLANDS	12	118
GREECE	11	225
SWEDEN	9	85
SWITZERLAND	9	90
BELGIUM	8	24
BRAZIL	7	1
DENMARK	7	0
POLAND	7	0
INDIA	6	0
FINLAND	5	4
MEXICO	4	0

Co-citation analysis and qualitative findings

Subsequently, a co-citation analysis divided in the three periods (1989-2011, 2012-2016 and 2017-2020) was carried to further explore whether exist relevant associations among authors.

A total of 5 co-citation networks appeared. In the first analysed timeframe (1989-2011), two co-citation networks emerged, representing the first contributions on FOPL and a sequence of articles published after the introduction of the Keyhole Logo in 1989.

Period 1989-2011: Discovering the relevance of nutrition-related information

This first period is characterized by the first European regulations on the subject of nutrition labels. In 1990, in fact, the European Commission proposed a regulation on information for packaged foods. Then, in 2011, with the "Regulation (EU) No 1169/2011", the topic of FOPL is introduced in a definitive way, without however inserting a mandatory use. In this first period, we mainly found two streams of studies (See S1): (i) the co-citation network 1 (in red in S1), oriented towards the drivers of misinterpretation of labels and the knowledge of consumers and (ii) the co-citation network 2 (in blue in S1), focused on the relevance of providing nutritional information through labels and their effects on healthier choices. The width of the line depicts the weight of the links between two nodes. The higher is the width, greater will be the number of times two authors cite each other. In co-citation network 1, the authors who share the greater number of link are, Chandon and Kozup, Balasubramanina and Moorman, Cacioppo and Kozup, Grunert and Kozup, Kozup and Garretson, Cacioppo and Mitra. In the co-citation network 2, the main link are those between Parmenter and Nayga and Gracia and Nayga.

Co-citation Network 1

In this period, EU consumer policies on FOPL start to emerge and are mainly aligned to the so-called "*information paradigm*". According to this paradigm, the higher is the level of information on foodstuff provided to consumers, the higher will be the awareness about the item they purchase and the likelihood to nudge buyers toward healthier choices. The main disadvantage of these assumptions is that they do not properly recognize the consumers' bounded rationality[9] and consider them as perfectly rationale in their decision-making process. However, from regulators' point of view, individuals are autonomous, dislike limitations and

[9] Bounded rationality relates to how individuals develop their decisions, moving away from the concept of perfect rationality. This happens as humans are restrained in their cognitive efforts, often forced under time-constraints or leveraging imperfect information in their decision-making. Thus, instead of making the perfect choices, consumers might make choices that are satisfactory.

able to take decision on their own. A feeling even grounded in European Court of Justice (1998) which observes consumers as perfectly reasonable, well-informed, adequately circumspect and able to read and process in-formation in the proper way.

The first attempt of EU regulation on FOPL, Council Directive 90/496/EEC (1990), leveraged on the aforementioned assumptions pointing out the relevance to support citizens' decisions with appropriate information on their diets. According to this Recital, the information paradigm has been respected. In this period of time, the authors belonging to such network in terms of co-citations (Andrews *et al.*, 1998; Andrews *et al.*, 2000; Roe *et al.*, 1999; Mitra *et al.*, 1999; Keller *et al.*, 1997; Burton *et al.*, 1994; Burton *et al.*, 1996; Burton *et al.*, 1999) defined the early stage of the research in nutrition labels and offered a series of contributions to investigate the comprehensibility of labels and the consequent ability of the consumer to understand and recognize them (Table 5 and 6).

At the very beginning of this stream of studies, Burton *et al.* (1994; 1996; 1999) highlighted the complexity of selecting a label that is easy for consumers to understand and showed how nutritional knowledge interacted with nutritional value in such a way that consumers with higher knowledge have higher likelihood of purchasing a product with better nutritional value (Burton *et al.*, 1994). In a subsequent work, he argued that the acceptance of the information varies according to the format of presentation of the label and stressed the need for further educational efforts to explain the information on the new labels (Burton *et al.*, 1996). In contrast, Keller *et al.* (1997) confirmed that the information normally contained on labels does not influence consumers' nutritional beliefs. This means that consumers prefer the presence of nutrition claims on the front of package and an in-dependent and detailed verification of nutritional values (Keller *et al.*, 1997). Roe *et al.* (1999) conducted a study on this topic and stated that nutrient and product health information have a significant effect on information processing and product evaluation. In particular, when information is clearly displayed, is an important tool in qualifying misleading impressions from nutrient content claims (Roe *et al.*, 1999). Other authors (Mitra *et al.*, 1999; Keller *et al.*, 1997; Burton *et al.*, 1994), added that in helping to remedy potential misinterpretations, becomes important the role of information, the level of nutritional knowledge and the type of advertising claims used (Andrews *et al.*, 1998). The use of elements contained in the disclosure would be useful in correcting potentially misleading omissions, as high nutritional levels may be perceived in a positive way in

conjunction with recommended total daily recommended values. Furthermore, it results in a more positive effect to use nutritional claims rather than others less specific (Andrews *et al.*, 2000). Conversely, according to Burton *et al.* (1999), many consumers seem to be able to understand nutritional information correctly and evaluate products in the best possible way thanks to it.

In 2008, the EU Commission developed a proposal (Hagenmeyer, 2008) and recognized the need to strengthen FOPL as tools able to fight obesity and to improve their effectiveness. This led to the modification of extant FOPL. In this regard, a parallel stream of research, became relevant in the FOPL literature in the following years, proposing a model to assess the antecedents of the acceptance of nutritional information. Indeed, Grunert & Wills (2007) revealed the complexities of nutrition labelling, and the difficulties consumers find with elements on labels such as technical terms and numerical calculations. In general, consumers understand the information on the product label, both in relation to individual nutrients and overall healthiness. Greater understanding is shown among consumers in the UK, Sweden, and Germany. Focusing on the UK, a greater understanding emerges overall since the UK has been at the forefront of FOPL in Europe. This is another reason why a lot of research has focused on this background, with Grunert & Wills (2007) continued researching the topic with other authors in 2010 and further adds that, most respondents had no difficulty in understanding the nutritional information in the FOPL and using it to make deductions about the healthiness of products (Grunert *et al.*, 2010).

Table 5. – Composition of co-citation network 1 in terms of authors, articles, year, country of authors and citation.

	Id	Authors	Articles	Year	Country of authors	Citation
1989-2011	*1*	Burton, S., Biswas, A., & Netemeyer, R.	Effects of Alternative Nutrition Label Formats and Nutrition Reference Information on Consumer Perceptions, Comprehension, and Product Evaluations	1994	USA	139
	2	Burton, S., & Andrews, J. C.	Age, Product Nutrition, and Label Format Effects on Consumer Perceptions and Product Evaluations	1996	USA	146
	3	Keller, S. B., Landry, M., Olson, J., Velliquette, A. M., Burton, S., & Andrews, J. C.	The Effects of Nutrition Package Claims, Nutrition Facts Panels, and Motivation to Process Nutrition Information on Consumer Product Evaluations	1997	USA	282
	4	Andrews, J. C., Netemeyer, R. G., & Burton, S.	Consumer Generalization of Nutrient Content Claims in Advertising	1998	USA	421
	5	Burton, S., Garretson, J. A., & Velliquette, A. M.	Implications of Accurate Usage of Nutrition Facts Panel Information for Food Product Evaluations and Purchase Intentions	1998	USA	184

6	Mitra, A., Hastak, M., Ford, G. T., & Ringold, D. J.	Can the Educationally Disadvantaged Interpret the FDA-Mandated Nutrition Facts Panel in the Presence of an Implied Health Claim?	1999	USA	121
7	Roe, B., Levy, A. S., & Derby, B. M.	The Impact of Health Claims on Consumer Search and Product Evaluation Outcomes: Results from FDA Experimental Data	1999	USA	594
8	Andrews, J. C., Burton, S., & Netemeyer, R. G.	Are Some Comparative Nutrition Claims Misleading? The Role of Nutrition Knowledge, Ad Claim Type and Disclosure Conditions	2000	USA	272
9	Grunert, K. G.	Current issues in the understanding of consumer food choice	2002	Denmark	655
10	Kozup, J. C., Creyer, E. H., & Burton, S.	Making Healthful Food Choices: The Influence of Health Claims and Nutrition Information on Consumers' Evaluations of Packaged Food Products and Restaurant Menu Items	2003	USA	863
11	Roe, B., & Sheldon, I.	Credence good labeling: The efficiency and distributional implications of several policy approaches	2007	USA	246
12	Grunert, K. G., & Wills, J. M.	A review of European research on consumer response to nutrition information on food labels	2007	Denmark, Belgium	1341
13	Grunert, K. G., Fernández-Celemín, L., Wills, J. M., Storcksdieck genannt Bonsmann, S., & Nureeva, L.	Use and understanding of nutrition information on food labels in six European countries	2007	Denmark, Belgium	440
14	Howlett, E., Burton, S., & Kozup, J.	How Modification of the Nutrition Facts Panel Influences Consumers at Risk for Heart Disease: The Case of Trans Fat	2008	USA	94
15	Teisl, M. F., Radas, S., & Roe, B.	Struggles in optimal labelling: how different consumers react to various labels for genetically modified foods	2008	USA	27
16	Feunekes, G. I., Gortemaker, I. A., Willems, A. A., Lion, R., & Van Den Kommer, M.	Front-of-pack nutrition labelling: Testing effectiveness of different nutrition labelling formats front-of-pack in four European countries	2008	The Netherlands	558
17	Vyth, E. L., Steenhuis, I. H., Mallant, S. F., Mol, Z. L., Brug, J., Temminghoff, M., ... & Seidell, J. C.	A Front-of-Pack Nutrition Logo: A Quantitative and Qualitative Process Evaluation in the Netherlands	2009	The Netherlands	132
18	Burton, S., Howlett, E., & Tangari, A. H.	Food for Thought: How Will the Nutrition Labeling of Quick Service Restaurant Menu Items Influence Consumers' Product Evaluations, Purchase Intentions, and Choices?	2009	USA	204
19	Wills, J. M., Grunert, K. G., Celemin, L. F., & BoNSMANN, S. S. G.	Do European consumers use nutrition labels	2009	Denmark, Belgium	12
20	genannt Bonsmann, S. S., & Grunert, E. K. G.	Food Labelling to Advance Better Education for Life	2010	Denmark, Belgium	57
21	Grunert, K. G., Wills, J. M., & Fernández-Celemín, L.	Nutrition knowledge, and use and understanding of nutrition information on food labels among consumers in the UK	2010	Denmark, Belgium	712
22	Andrews, J. C., Burton, S., & Kees, J.	Is Simpler Always Better? Consumer Evaluations of Front-of-Package Nutrition Symbols	2011	USA	229

Table 6. – The relative strength of the nodes within the co-citation network

Node	Co-citation network	Betweenness	Closeness	PageRank
Burton S	1	475,7513	0,0052	0,0267
Kozup JC	1	38,6570	0,0045	0,0299
Grunert KG	1	34,7742	0,0044	0,0212
Roe B	1	15,5871	0,0044	0,0263

Keller SB	1	15,5860	0,0044	0,0282
Mitra A	1	7,0525	0,0042	0,0250
Moorman C	1	5,9589	0,0041	0,0265
Garretson JA	1	4,0021	0,0042	0,0202
Balasubramanian SK	1	3,2255	0,0043	0,0252
Feunekes GI	1	2,3474	0,0042	0,0186
Jacoby J	1	1,2850	0,0042	0,0195
Chandon P	1	0,9064	0,0040	0,0192
Chaiken S	1	0,4333	0,0028	0,0234
Cacioppo JT	1	0,4333	0,0028	0,0234
Andrews JC	1	0,0000	0,0027	0,0196

Co-citation Network 2

In this co-citation network, authors mainly focused on the importance of using labels to make consumers more health-conscious and the relevance of providing truthful information (Table 7 and 8). Similarly to the co-citation network 1, these authors belong to the early stage of the literature on FOPL and seem positioned in a causal relationship with the Directive 90/496/EEC (1990) which introduced to nutritional labelling without a high awareness on their effectiveness. The research, in this period of time, shed light on the main effect of the labels and supported the evolution of regulations.

The first contribution comes from the study conducted by Ippolito & Mathios (1993), which states that a focus on increasing the truthful of information flow is necessary for a good consumer policy.

In addition, Levy *et al.* (1996) argued that the nature of the information and the way it is presented affect the understanding and preference of the labels, evidencing that the most impactful format features lower decision-related efforts required by a situational task. Gracia *et al.* (2009) confirmed this evidence by stating that consumers' product perceptions differ according to the way the information (facts or claims) and the type of information (nutrition or health) are presented.

Furthermore, the research conducted by Teisl *et al.* (1999; 2001) asserted that the adoption of an information campaign to educate consumers together with the labelling of products to highlight to their nutritional characteristics are important to prompt consumers toward healthier choices. While Loureiro *et al.* (2006) demonstrated that information about the nutritional

content of food products through nutrition labels can make consumers more informed and thus help them to make healthier food choices and follow healthier diets. The between nutritional labels and healthier choices.

Other authors (Ippolito *et al.*, 1993), few years before, outlined a distinction between the information on the nutrition panel and front of the pack information, demonstrating that nutrition panel on the back-of-a-pack may provide much useful information when the consumer is interested but may be relatively ineffective in generating consumer interest.

In subsequent research emerged the importance to know the factors that determine consumers' use of food labels to improve the effectiveness of food labelling policies. They found different factors affect the usage of labels, such as household food expenditure, income, household size, education, and race of the head of household, urbanization and region of residence (Wang *et al.*, 1995). Wansink *et al.* (2004) added that people show a more positive attitude towards short indications than long ones on FOPL while, Wang *et al.* (1995) argued that consumers are positively influenced by more descriptive and informative labels. Similarly, Wansink *et al.* (2004) confirmed that descriptive labels influence consumers' intention to repurchase the labelled food directly and indirectly through the overall evaluation of the labelled food.

Finally, concerning the willingness to pay for the product, other research (Vaqué, 2016; Signal *et al.*, 2012) shows that subjects' willingness to pay is higher for products with nutritional information than for products without nutritional information. Moreover, the research suggested that product evaluation is affected by the quantum of nutrition appearing on the label.

Table 7. – Composition of co-citation network 2 in terms of authors, articles, year, country of authors and citation.

Year	#	Authors	Articles	Year	Country of authors	Citation
1989-2011	*1*	Schucker, R. E., Levy, A. S., Tenney, J. E., & Mathews, O.	Nutrition Shelf-Labeling ad Consumer Purchase Behavior	1992	USA	66
	2	Ippolito, P. M., & Mathios, A. D	New Food Labeling Regulations and the Flow of Nutrition Information to Consumers	1993	USA	103
	3	Wang, G., Fletcher, S. M., & Carley, D. H.	Consumer Utilization of Food Labeling as a Source of Nutrition Information	1995	USA	142

4	Guthrie, J. F., Fox, J. J., Cleveland, L. E., & Welsh, S.	Who Uses Nutrition Labeling, and What Effects Does Label Use Have on Diet Quality?	1995	USA	378
5	Levy, A. S., Fein, S. B., & Schucker, R. E.	Performance Characteristics of Seven Nutrition Label Formats	1996	USA	191
6	Levy, A. S. & Fein, S. B.	Consumers' Ability to Perform Tasks Using Nutrition Labels	1998	USA	194
7	Teisl, M. F., Levy, A. S., & Derby, B. M.	The Effects of Education and Information Source on Consumer Awareness of Diet-Disease Relationships	1999	USA	66
8	Coulson, N. S.	An application of the stages of change model to consumer use of food labels	2000	UK	162
9	Teisl, M. F., Bockstael, N. E., & Levy, A.	Measuring the Welfare Effects of Nutrition Information	2001	USA	237
10	Wansink, B., Painter, J., & Ittersum, K. V.	How Descriptive Menu Labels Influence Attitudes and Repatronage	2002	USA	11
11	Wansink, B., Sonka, S. T., & Hasler, C. M.	Front-label health claims: when less is more	2004	USA	196
12	Wansink, B., Painter, J., & Ittersum, K. V.	How Diet and Health Labels Influence Taste and Satiation	2004	USA	105
13	Drichoutis, A. C., Lazaridis, P., & Nayga Jr, R. M.	Nutrition knowledge and consumer use of nutritional food labels	2005	Greece	425
14	Wansink, B., & Chandon, P.	Can “Low-Fat” Nutrition Labels Lead to Obesity?	2006	France	919
15	Loureiro, M. L., Gracia, A., & Nayga Jr, R. M.	Do consumers value nutritional labels?	2006	Spain	124
16	Drichoutis, A. C., Lazaridis, P., & Nayga Jr, R. M.	An assessment of product class involvement in food-purchasing behavior	2007	Greece, USA	91
17	Roe, B. & Teisl, M. F.	Genetically modified food labeling: The impacts of message and messenger on consumer perceptions of labels and products	2007	USA	130
18	Gracia, A., Loureiro, M. L., & Nayga Jr, R. M.	Do consumers perceive benefits from the implementation of a EU mandatory nutritional labelling program?	2007	Spain	107
19	Drichoutis, A. C., Lazaridis, P., Nayga, R. M., Kapsokefalou, M., & Chryssochoidis, G.	A theoretical and empirical investigation of nutritional label use	2008	Greece, USA	133
20	Radas, S., Teisl, M. F., & Roe, B.	An Open Mind Wants More: Opinion Strength and the Desire for Genetically Modified Food Labeling Policy	2008	Croatia, USA	35
21	Variyam, J. N.	Do nutrition labels improve dietary outcomes?	2008	USA	241
22	Golan, E., & Unnevehr, L.	Food product composition, consumer health, and public policy: Introduction and overview of special section	2008	USA	78
23	Teisl, M. F., Radas, S., & Roe, B.	Struggles in optimal labelling: how different consumers react to various labels for genetically modified foods	2008	USA, Croatia	27
24	Drichoutis, A. C., Nayga, Jr, R. M., & Lazaridis, P.	Can Nutritional Label Use Influence Body Weight Outcomes?	2009	Greece, USA	68

25	Gracia, A., Loureiro, M. L., & Nayga Jr, R. M.	Consumers' valuation of nutritional information: A choice experiment study	2009	Spain, USA	137
26	Puduri, V., Govindasamy, R., & Onyango, B.	Country of origin labelling of fresh produce: a consumer preference analysis	2009	USA	22
27	Barreiro-Hurlé, J., Gracia, A., & De-Magistris, T.	Market implications of new regulations: impact of health and nutrition information on consumer choice	2009	Spain	29
28	Drichoutis, A. C., Lazaridis, P., & Nayga Jr, R. M.	ON CONSUMERS' VALUATION OF NUTRITION INFORMATION	2009	Greece, USA	45
29	Drichoutis, A. C., Lazaridis, P., & Nayga Jr, R. M.	Would Consumers Value Food-Away-From-Home Products With Nutritional Labels?	2009	Greece	42
30	Barreiro-Hurlé, J., Gracia, A., & De-Magistris, T.	Does nutrition information on food products lead to healthier food choices?	2010	Spain	269
31	Barreiro-Hurlé, J., Gracia, A., & De-Magistris, T.	The Effects of Multiple Health and Nutrition Labels on Consumer Food Choices	2010	Spain	91
32	Golan, E., & Kuchler, F.	The Effect of GM Labeling Regime on Market Outcomes	2011	USA	6

In the first two co-citation networks, clearly appears the interplay between the literature and the regulations. The first is aligned to the regulations and the latter, in this period of time, guides the research. In addition, consumers in this period started to be aware of labels, able to understand the nutritional information which inform the decision. The co-citation network 1 is focused on the investigation on what drives the understanding of consumers, whereas the co-citation network 2 in mainly focused on the antecedent of the usage of nutritional labels.

Table 8. – The relative strength of the nodes within the co-citation network 2.

Node	Co-citation network	Betweenness	Closeness	PageRank
Nayga RM	2	163,0369	0,0048	0,0336
Wansink B	2	127,1826	0,0047	0,0257
Stigler GJ	2	80,0827	0,0045	0,0336
Ippolito PM	2	53,3569	0,0047	0,0235
Variyam JN	2	28,6655	0,0045	0,0215
Szykman LR	2	27,1180	0,0046	0,0210
Levy AS	2	18,1432	0,0045	0,0193
Kim SY	2	6,7404	0,0045	0,0256
Nayga R M JR	2	6,7404	0,0045	0,0256
Wang GJ	2	6,7404	0,0045	0,0256
Drichoutis AC	2	3,6414	0,0044	0,0240
Govindasamy R	2	3,2936	0,0044	0,0253
Guthrie JF	2	1,0827	0,0044	0,0205
Kim S Y	2	1,0827	0,0044	0,0205
Mcleanmeyinsse P E	2	1,0827	0,0044	0,0205
Gracia A	2	1,0537	0,0044	0,0209
Coulson N S	2	0,9562	0,0044	0,0231
Caswell JA	2	0,0000	0,0024	0,0157
Parmenter K	2	0,0000	0,0027	0,0207
Teisl MF	2	0,0000	0,0026	0,0186
Blaylock J	2	0,0000	0,0027	0,0207
Golan E	2	0,0000	0,0043	0,0190
Grossman M	2	0,0000	0,0025	0,0152
Lancaster KJ	2	0,0000	0,0024	0,0157

Period: 2012 – 2016 - The drivers of acceptance of Front-of-Pack labels

In the second timeframe (2012-2016), appear the first effects of regulations and new FOPL introductions (such as Guideline Daily Amount, MTL, Fact Up Front and NS). Two main co-citation networks are highlighted and new authors appear while other established authors remain (See S2). The co-citation network 3, in red in S2, is mainly focused on 5-Color Nutrition Label (today known as Nutri-Score) while the co-citation network 4, in blue in S2, on all other labels that have emerged over time. The strongest link in co-citation network 3 are those between Julia and Hercberg, Julia and Mejean, Rayner and Bialkova, Julia and Cowburn, Van Herpen and Borgmeier and Mejean and Cowburn. In network 4, the strongest links appears between Grunert and Moorman, Casweel and Moorman, Roberto and Grunert, Kozup and Wansink.

Co-citation Network 3

With the Regulation 1169/2011, the EU required the mandatory provision of nutrition information on packaging to support consumers' decisions and defeat obesity-related issues. Also, the Recitals recognize the need to make FOPL appealing for the average consumers and suggest the need of easy and recognizable labels to facilitate the assessment of nutritional values (Vaqué, 2016). An advancement that reflect the evolution of the policies and the implied paradigms. Beyond the classic "information paradigm" and the active role of FOPL in the Proposal outlined in 2008, the Regulation 1169/2011 (17) lay down the foundations for a central role of FOPL in the fight against obesity and their roles in orienting and affecting consumers' choices. The Food Information to Consumers (FIC) Regulation allows Member States and operators to try their own proposals to help consumers. As a result, the literature in this period welcome many studies about new FOPL designed by Member States. In this test-phase, the research is divided in two main streams: one focused on the NS and one based on the comparison of other labels.

Co-citation network 3, indeed, mainly focuses on the development of the NS label and the ease of use of information given to consumers through labels (Table 9 and 10). One of the first studies, subsequent to the EU Regulation 1169/2011, was conducted by Signal *et al.* (2012) which discussed the benefits provided by FOPL to consumers, including the provision of simple

and easily understandable information and are intended as tools able to communicate information about the nutrients and healthiness (van Harpen *et al.*, 2014). In addition, Schwartz *et al.* (2012), posited that FOPL improved the accuracy of judgements about foods.

In general, drawing on these authors, Ducrot *et al.* (2015) states the presence of labels makes it easier for consumers to classify products according to their nutritional quality. However, such labels help to inform consumers but do not influence their choices and thus change their perceptions of health, taste, and purchase intention (Bonsmann *et al.*, 20106). In turn, a good FOPL should at least be able to encourage food manufacturers to reformulate products (Signal *et al.*, 2012; van Harpen *et al.*, 2012). In addition, other potential limits of FOPL outlined in this network, are the lack of agreement on the labelling format, limited evidence on which to base this decision, potential opposition from the food industry, conflict of values between the food industry and public health, etc. (Signal *et al.*, 2012).

Furthermore, other authors explained the relevance of individuals' boundaries that lead to reduced usage of FOPL. Bonsmann *et al.* (2010), for instance, added that the lack of attention and the lack of motivation toward FOPL's usage is due to the fact that organoleptic features of food are the main reasons for choosing products. Consumers are influenced by a priori familiarity much more than by the use and effect of labelling schemes (van Harpen *et al.*, 2012).

Additionally, the level of detail depicted in a FOPL is highly relevant for final acceptance (Hodgkins *et al.*, 2012). Labels with a lot of information are likely to convince more consumers since they offer in-depth details about the product (Ducrot *et al.*, 2016). FOPL labels showing numerical and text information are more difficult for consumers to understand (Hersey *et al.*, 2013). In contrast, FOPL based on colours and graded indicators seem less complicated (Méjan *et al.*, 2013).

However, the acceptance of FOPL varies on a scale according to the overall *liking*, *understanding*, attractiveness and the perceived cognitive workload (Méjan *et al.*, 2013). For instance, it has been proved that Graded Summary labels, such as the more recent NS (in that initial period known as NutriNet-Santé or 5-Color Nutrition Label), are easier to understand (Ducrot *et al.*, 2015; Julia *et al.*, 2015). The label represents a coloured scale (from green to red) to indicate the goodness of the balance of nutritive values (Julia *et al.*, 2015) and summarizes the nutritional quality of the food or beverage. According to Julia *et al.* (2015b;

2016), this makes it possible to properly discriminate the nutritional quality of foods at various levels and prompts individuals toward the choice of healthier products. In addition, this label seemed to positively influence consumers' eating habits and their quality of life (Grunert *et al.*, 2014). Ducrot *et al.* (2015) confirmed that the 5-CNL label, according to consumers, was the easiest label to understand and highlighted a greater efficacy in consumers with no nutritional knowledge

This co-citation network reflects a stream of studies based on the investigation of NS label and its effects. While in the other networks there is an heterogeneity of topics, in this networks, over the analysed timespan, there is a clear convergence on the topic and the country of origin of the authors, which links to national perspective of adoption of specific labels.

Table 9. – Composition of co-citation network 3 in terms of authors, articles, year, country of authors and citation.

Year	#	Authors	Articles	Year	Country of authors	Citation
2011-2016	*1*	Roberto, C. A., Bragg, M. A., Schwartz, M. B., Seamans, M. J., Musicus, A., Novak, N., & Brownell, K. D.	Facts Up Front Versus Traffic Light Food Labels	2012	USA	156
	2	Signal, L., Lanumata, T., Mhurchu, C. N., & Gorton, D.	Front-of-pack nutrition labelling in New Zealand: an exploration of stakeholder views about research and implementation	2012	USA	5
	3	Storcksdieck genannt Bonsmann, S., & Wills, J. M.	Nutrition Labeling to Prevent Obesity: Reviewing the Evidence from Europe	2012	Belgium	71
	4	Eric van Herpen, Ellen Seissb, Hans C.M. Van Trijpc	The role of familiarity in front-of-pack label evaluation and use: A comparison between the United Kingdom and The Netherlands	2012	The Netherlands	61
	5	Hodgkins, C., Barnett, J., Wasowicz-Kirylo, G., Stysko-Kunkowska, M., Gulcan, Y., Kustepeli, Y., ... & Raats, M.	Understanding how consumers categorise nutritional labels: A consumer derived typology for front-of-pack nutrition labelling	2012	UK, Poland, Turkey, Belgium, Greece	169
	6	Aschemann-Witzel, J., Grunert, K. G., van Trijp, H. C., Bialkova, S., Raats, M. M., Hodgkins, C., ... & Koenigstorfer, J.	Effects of nutrition label format and product assortment on the healthfulness of food choice	2013	The Netherlands, UK, , Poland, Germany	183
	7	M. Rayner, A. Wood, M. Lawrence, C. N. Mhurchu, J. Albert, S. Barquera, S. Friel, C. Hawkes, B. Kelly, S. Kumanyika, M. L'Abbé, A. Lee, T. Lobstein, J. Ma, J. Macmullan, S. Mohan, C. Monteiro, B. Neal, G. Sacks, D. Sanders, W. Snowdon, B. Swinburn, S. Vandevijvere and C. Walker	Monitoring the health-related labelling of foods and non-alcoholic beverages in retail settings	2013	UK, New Zealand, Italy, Australia, Canada, Switzerland	121
	8	Hawley, K. L., Roberto, C. A., Bragg, M. A., Liu, P. J., Schwartz, M. B., & Brownell, K. D.	The science on front-of-package food labels	2013	USA	497
	9	Mejean, C., Macouillard, P., Péneau, S., Hercberg, S., & Castetbon, K.	Consumer acceptability and understanding of front-of-pack nutrition labels	2013	France	85
	10	Hersey, J. C., Wohlgenant, K. C., Arsenault, J. E., Kosa, K. M., & Muth, M. K.	Effects of front-of-package and shelf nutrition labeling systems on consumers	2013	USA	369

11	Mejean, C., Macouillard, P., Péneau, S., Hercberg, S., & Castetbon, K.	Perception of front-of-pack labels according to social characteristics, nutritional knowledge and food purchasing habits	2013	France	84
12	Andrews, J. C., Lin, C. T. J., Levy, A. S., & Lo, S.	Consumer Research Needs from the Food and Drug Administration on Front-of-Package Nutritional Labeling	2014	USA	81
13	Van Herpen, E., Hieke, S., & Van Trijp, H. C.	Inferring product healthfulness from nutrition labelling. The influence of reference points	2014	The Netherlands, Germany	58
14	Devi, A., Eyles, H., Rayner, M., Mhurchu, C. N., Swinburn, B., Lonsdale-Cooper, E., & Vandevijvere, S.	Nutritional quality, labelling and promotion of breakfast cereals on the New Zealand market	2014	New Zealand, UK, Australia	74
15	Méjean, C., Macouillard, P., Péneau, S., Lassale, C., Hercberg, S., & Castetbon, K.	Association of Perception of Front-of-Pack Labels with Dietary, Lifestyle and Health Characteristics	2014	France	35
16	Volkova, E., Neal, B., Rayner, M., Swinburn, B., Eyles, H., Jiang, Y., ... & Ni Mhurchu, C	Effects of interpretive front-of-pack nutrition labels on food purchases: protocol for the Starlight randomised controlled trial	2014	New Zeland	23
17	Julia, C., Ducrot, P., Péneau, S., Deschamps, V., Méjean, C., Fézeu, L., ... & Kesse-Guyot, E.	Discriminating nutritional quality of foods using the 5-Color nutrition label in the French food market: consistency with nutritional recommendations	2015	France	64
18	Ducrot, P., Julia, C., Méjean, C., Kesse-Guyot, E., Touvier, M., Fezeu, L. K., ... & Péneau, S.	Objective Understanding of Front-of-Package Nutrition Labels among Nutritionally At-Risk Individuals	2015	France	98
19	Julia, C., Touvier, M., Méjean, C., Ducrot, P., Péneau, S., Hercberg, S., & Kesse-Guyot, E.	Performance of a five category front-of-pack labelling system – the 5-colour nutrition label – to differentiate nutritional quality of breakfast cereals in France	2015	France	71
20	Ducrot, P., Julia, C., Méjean, C., Kesse-Guyot, E., Touvier, M., Fezeu, L. K., ... & Péneau, S.	Impact of Different Front-of-Pack Nutrition Labels on Consumer Purchasing Intentions A Randomized Controlled Trial	2016	France	182
21	Julia, C., Blanchet, O., Méjean, C., Péneau, S., Ducrot, P., Allès, B., ... & Hercberg, S.	Impact of the front-of-pack 5-colour nutrition label (5-CNL) on the nutritional quality of purchases: an experimental study	2016	France	82
22	Fenko, A., Kersten, L., & Bialkova, S.	Overcoming consumer scepticism toward food labels: The role of multisensory experience	2016	The Netherlands	96
23	Hieke, S., Kuljanic, N., Pravst, I., Miklavec, K., Kaur, A., Brown, K. A., ... & Rayner, M.	Prevalence of Nutrition and Health-Related Claims on Pre-Packaged Foods: A Five-Country Study in Europe	2016	Belgium, Spain, Germany, Slovenia	90
24	Julia, C., Méjean, C., Péneau, S., Buscail, C., Alles, B., Fezeu, L., ... & Kesse-Guyot, E.	The 5-CNL Front-of-Pack Nutrition Label Appears an Effective Tool to Achieve Food Substitutions towards Healthier Diets across Dietary Profiles	2016	France	23

Table 10. – The relative strength of the nodes within the co-citation network 3

Node	Co-citation network	Betweenness	Closeness	PageRank
Julia C	3	0,4858	0,0071	0,0191
Hercberg S	3	1,4783	0,0074	0,0201
Rayner M	3	1,4783	0,0074	0,0201
Feunekes GI	3	280,0777	0,0094	0,0213
Vyth EL	3	1,4185	0,0074	0,0185
Cowburn G	3	184,7231	0,0093	0,0203
Food Standards Agency	3	9,4425	0,0078	0,0196
Hawley KL	3	78,2377	0,0085	0,0208
Mejean C	3	0,9160	0,0074	0,0185
Bialkova S	3	10,7832	0,0078	0,0184
Bonsmann SSG	3	16,5462	0,0078	0,0181
Campos S	3	73,9718	0,0083	0,0199
Hersey JC	3	24,1884	0,0082	0,0197
Sacks G	3	1,1089	0,0072	0,0184
Who	3	17,9771	0,0077	0,0191

Borgmeier I	3	8,7401	0,0075	0,0184
Van Herpen E	3	15,0560	0,0082	0,0193
Ducrot P	3	0,0216	0,0068	0,0161
Gorton D	3	45,7196	0,0079	0,0178
Schwartz MB	3	15,8411	0,0071	0,0165

Co-citation Network 4

As opposite to the previous network, the present component of the literature is dominated by a fragmentation of the contributions and a clear heterogeneity of the topics/labels investigated (Table 11 and 12). A set of articles which compare the effectiveness of other FOPL emerged in the second period, such as the Smart Choices (SM), Multiple Traffic Light and Health Logo. In addition, many authors from the co-citation network 2 of the timespan 1989-2011, are now belonging to this one (Grunert *et al.*, 2016; Roberto *et al.*, 2021; Kleef *et al.*, 2015; Andrews *et al.*, 2014; Hodgkins *et al.*, 2015).

Some authors (Kleef *et al.*, 2015) showed that a FOPL can improve the accuracy of judgments about the nutritional quality of foods and beverages, and consumers are encouraged to make healthier choices if nutritional criteria are present in a clear way. Consumers, over time, have become increasingly able to distinguish the various degrees of the healthiness of foods through the various types of labels and key nutrient information (Hodgkins *et al.*, 2015). They inform the consumer toward healthier choices (Andrews *et al.*, 2014). Grunert *et al.* (2016) added that nutrition labels do not increase the healthy choices made by consumers, but they increase the ability of consumers to make informed choices and understand which products are healthier. According to Talati *et al.* (2016; 2016b), consumers think that FOPL are valuable sources of nutrition information since they are controlled by regulators and that health claims should be reliable, relevant, and informative, while FOPL should be trustworthy and easy to understand. However, there is still a need to implement a uniform, consistent and credible labelling system (Roberto *et al.*, 2014).

Among the proposed FOPL, in this timeframe the SM label has been introduced. Roberto *et al.* (2012), affirmed that the label was able to increase consumers' ability to understand the calories per serving of food while decreasing their ability to decide the adequate quantity of products to consume. Additionally, he argued that Smart Choices and Multiple Traffic Light (MTL) perform similarly in educating the consumer while MTL labels is better in estimating nutrient amounts since the SM does not highlight a detailed depiction of nutritive values

(Bonsmann *et al.*, 2010). In general, the MTL label seems to be the most effective FOPL (tangari *et al.*, 2014). By examining the effects of saturated fat and sodium on consumer health, consumers tended to respond more favourably to the numbers rather than percentages (Wasowicz *et al.*, 2015). Moreover, MTL can rely both on colours and text, that are relevant elements in the la-belling system, as they help draw attention to the label and consequently to its contents (Andrews *et al.*, 2014). Research carried out by Wąsowicz *et al.* (2015) showed that Multiple Traffic Light (MTL) colours, such as green, amber and red were associated to healthy fruits and vegetables and their combination was evaluated as appropriate to highlight unhealthy products. While the Health Logo (HL) was associated with a sense of healthiness (Lee *et al.*, 2013).

Another analysed FOPL is the organic label. In fact, food companies that have used the organic label in their products have definitely obtained positive results because of healthier associations attached to foods with the presence of organic cues (Liu *et al.*, 2012). In addition, the FOPL are starting to appear on menus, where, primarily, calories information should be presented. One idea is to base menu labelling on the colour scheme used in the "traffic light" labelling system, where different colours indicate levels of various elements and can even educate consumers (Roberto *et al.*, 2014; Egnell *et al.* 2019). The introduction of menu labelling has led to different consequences. For example, in fast-food restaurants, there was no obvious alteration in the products purchased by consumers. On the other hand, this alteration was most apparent in settings such as miscellaneous and service restaurants, where customers are encouraged to purchase less energy (Liu *et al.*, 2012).

The networks in this period welcomed the new regulations developing a sequence of studies to test the effects of the labels on consumers. Oftentimes, they tended to compare the alternatives in different countries without arriving to univocal results.

Table 11. – Composition of co-citation network 4 in terms of authors, articles, year, country of authors and citation.

	Id	Authors	Articles	Year	Country of authors	Citation
2012-2016	*1*	Liu, P. J., Roberto, C. A., Liu, L. J., & Brownell, K. D.	A test of different menu labeling presentations	2012	USA	139
	2	Roberto, C. A., Bragg, M. A., Livingston, K. A., Harris, J. L., Thompson, J. M., Seamans, M. J., & Brownell, K. D.	Choosing front-of-package food labelling nutritional criteria: how smart were 'Smart Choices'?	2012	USA	39

3	Roberto, C. A., Bragg, M. A., Schwartz, M. B., Seamans, M. J., Musicus, A., Novak, N., & Brownell, K. D. (	Facts Up Front Versus Traffic Light Food Labels A Randomized Controlled Trial	2012	USA	158
4	Roberto, C. A., Shivaram, M., Martinez, O., Boles, C., Harris, J. L., & Brownell, K. D.	The Smart Choices front-of-package nutrition label. Influence on perceptions and intake of cereal	2012	USA	104
5	Moorman, C., Ferraro, R., & Huber, J.	Unintended Nutrition Consequences: Firm Responses to the Nutrition Labeling and Education Act	2012	USA	91
6	Roberto, C. A., Bragg, M. A., Seamans, M. J., Mechulan, R. L., Novak, N., & Brownell, K. D.	Evaluation of Consumer Understanding of Different Front-of-Package Nutrition Labels, 2010–2011	2012	USA	68
7	Sacks, G., Swinburn, B., Kraak, V., Downs, S., Walker, C., Barquera, S., ... & INFORMAS.	A proposed approach to monitor private-sector policies and practices related to food environments, obesity and non-communicable disease prevention	2013	Australia, New Zealand, USA, UK	84
8	Martinez, O. D., Roberto, C. A., Kim, J. H., Schwartz, M. B., & Brownell, K. D.	A Survey of undergraduate student perceptions and use of nutrition information labels in a university dining hall	2013	USA	53
9	Aschemann-Witzel, J., Grunert, K. G., van Trijp, H. C., Bialkova, S., Raats, M. M., Hodgkins, C., ... & Koenigstorfer, J.	Effects of nutrition label format and product assortment on the healthfulness of food choice	2013	Denmark, The Netherlands, UK, Poland, Germany	183
10	Wendy L Watson, Kathy Chapman, Lesley King, Bridget Kelly, Clare Hughes, Jimmy Chun Yu Louie, Jennifer Crawford and Timothy P Gill	How well do Australian shoppers understand energy terms on food labels?	2013	Australia	49
11	Joseph, S., Lavoie, N., & Caswell, J. A.	Implementing COOL: Comparative welfare effects of different labeling schemes	2013	USA	13
12	Rayner, M., Wood, A., Lawrence, M., Mhurchu, C. N., Albert, J., Barquera, S., ... & INFORMAS.	Monitoring the health-related labelling of foods and non-alcoholic beverages in retail settings	2013	UK, Italy, USA	122
13	Bialkova, S., Grunert, K. G., & van Trijp, H.	Standing out in the crowd: The effect of information clutter on consumer attention for front-of-pack nutrition labels	2013	Denmark, The Netherlands	111
14	Hawley, K. L., Roberto, C. A., Bragg, M. A., Liu, P. J., Schwartz, M. B., & Brownell, K. D.	The science on front-of-package food labels	2013	USA	497
15	Lee, W. C. J., Shimizu, M., Kniffin, K. M., & Wansink, B	You taste what you see: Do organic labels bias taste perceptions?	2013	USA	387
16	Bialkova, S., Grunert, K. G., Juhl, H. J., Wasowicz-Kirylo, G., Stysko-Kunkowska, M., & van Trijp, H. C.	Attention mediates the effect of nutrition label information on consumers' choice. Evidence from a choice experiment involving eye-tracking	2014	Denmark, The Netherlands, Poland	155
17	Watson, W. L., Kelly, B., Hector, D., Hughes, C., King, L., Crawford, J., ... & Chapman, K.	Can front-of-pack labelling schemes guide healthier food choices? Australian shoppers' responses to seven labelling formats	2014	Australia	127
18	Dixon, H., Scully, M., Kelly, B., Donovan, R., Chapman, K., & Wakefield, M.	Counter-Advertising May Reduce Parent's Susceptibility to Front-of-Package Promotions on Unhealthy Foods	2014	Australia	23
19	Roberto, C. A., & Khandpur, N.	Improving the design of nutrition labels to promote healthier food choices and reasonable portion sizes	2014	USA	152
20	Newman, C. L., Howlett, E., & Burton, S.	Shopper Response to Front-of-Package Nutrition Labeling Programs: Potential Consumer and Retail Store Benefits	2014	USA	107

21	Grunert, K. G., Hieke, S., & Wills, J.	Sustainability labels on food products: Consumer motivation, understanding and use	2014	Denmark, Belgium	1050
22	Andrews, J. C., Lin, C. T. J., Levy, A. S., & Lo, S.	Consumer Research Needs from the Food and Drug Administration on Front-of-Package Nutritional Labeling	2014	USA	81
23	Kauer, J., Pelchat, M. L., Rozin, P., & Zickgraf, H. F.	Adult picky eating. Phenomenology, taste sensitivity, and psychological correlates	2015	USA	122
24	Hodgkins, C. E., Raats, M. M., Fife-Schaw, C., Peacock, M., Gröppel-Klein, A., Koenigstorfer, J., ... & Grunert, K. G.	Guiding healthier food choice: systematic comparison of four front-of-pack labelling systems and their effect on judgements of product healthiness	2015	UK, Poland, Turkey, Denmark	62
25	Kleef, E. V., & Dagevos, H.	The Growing Role of Front-of-Pack Nutrition Profile Labeling: A Consumer Perspective on Key Issues and Controversies	2015	The Neterlands	214
26	Wąsowicz, G., Styśko-Kunkowska, M., & Grunert, K. G.	The meaning of colours in nutrition labelling in the context of expert and consumer criteria of evaluating food product healthfulness	2015	Poland, Denmark	27
27	Grunert, K. G., & Aachmann, K.	Consumer reactions to the use of EU quality labels on food products: A review of the literature	2016	Denmark	195
28	Talati, Z., Pettigrew, S., Kelly, B., Ball, K., Dixon, H., & Shilton, T.	Consumers' responses to front-of-pack labels that vary by interpretive content	2016	Australia	73
29	Newman, C. L., Howlett, E., & Burton, S.	Effects of Objective and Evaluative Front-of-Package Cues on Food Evaluation and Choice: The Moderating Influence of Comparative and Noncomparative Processing Contexts	2016	UK	61
30	VanEpps, E. M., Roberto, C. A., Park, S., Economos, C. D., & Bleich, S. N.	Restaurant Menu Labeling Policy: Review of Evidence and Controversies	2016	USA	102
31	Talati, Z., Pettigrew, S., Hughes, C., Dixon, H., Kelly, B., Ball, K., & Miller, C.	The combined effect of front-of-pack nutrition labels and health claims on consumers' evaluation of food products	2016	Australia	51
32	Qi, D., & Roe, B. E.	Household Food Waste: Multivariate Regression and Principal Components Analyses of Awareness and Attitudes among U.S. Consumers	2016	USA	205

Table 12. – The relative strength of the nodes within the co-citation network 4.

Node	Co-citation network	Betweenness	Closeness	PageRank
Wansink B	4	75,6265	0,0088	0,0276
Grunert KG	4	248,3855	0,0100	0,0261
Roberto CA	4	62,7962	0,0089	0,0202
Moorman C	4	4,4328	0,0072	0,0212
Andrews JC	4	2,1948	0,0070	0,0209
Kozup JC	4	15,3196	0,0081	0,0253
Burton S	4	0,6517	0,0064	0,0229
Chandon P	4	0,0000	0,0064	0,0195
Keller SB	4	6,2964	0,0076	0,0240
Rozin P	4	0,0000	0,0031	0,0171

Viswanathan M	4	2,1404	0,0068	0,0197
Kelly B	4	99,2021	0,0094	0,0226
Van Kleef E	4	100,5196	0,0094	0,0223
Caswell JA	4	49,2315	0,0070	0,0277
Petty RE	4	0,0000	0,0058	0,0163
Drewnowski A	4	0,0000	0,0032	0,0202
Drichoutis AC	4	3,7479	0,0072	0,0190
Levy AS	4	6,7481	0,0078	0,0191
Roe B	4	5,4736	0,0078	0,0204
Nestle M	4	2,2088	0,0068	0,0194
Finkelstein EA	4	4,4040	0,0063	0,0202
Food Marketing Institute	4	0,0000	0,0026	0,0151
Harris JL	4	0,9498	0,0060	0,0189
Just DR	4	0,0000	0,0029	0,0163
Nayga RM	4	0,0000	0,0030	0,0169
Verbeke W	4	2,6675	0,0069	0,0197
Williams P	4	0,2657	0,0065	0,0180
Flegal KM	4	4,5540	0,0066	0,0208

Period: 2017 – 2020 – Opening up to alternatives and challenging the mainstream

In the third period, important new research streams emerged. This period is characterized by the introduction of the NS in France (2017) and then over time in other countries, such as Belgium (2018), Germany and Switzerland (2020). In this context, the two co-citation networks of the previous period continue to develop new studies along two trajectories: one group focused on the NS (co-citation network 3 in blue) and a second focused on the other labels (co-citation network 4 in red). In co-citation network 3, the strongest links are those between Chantal and Julia (same author, with two different references), Julia and Egnell, Julia and Donnenfeld, Chantal and Ducrot, Vith and Ducrot, Ducrot and Crosetto and Crosetto and Hersey, with a strong recurrence of the same country of affiliation. As for co-citation network 4, are those between Grunert and Graham. In addition, emerged another co-citation network (5, in green), focused on the importance of the FOPL and the relevance for the policy makers about the chosen labels. In this network, there is an equally distributed weight across all the links.

Co-citation Network 5

From 16 December 2016, started the obligation to provide nutrition information as regulated by the Regulation (EU) 1169/2011. In this period, there has been a consolidation of past research stream focused on specific FOPL and the formation of new ones (Table 13 and 14).

The current co-citation network evolved from the previous period and the focus continues to be on the NS, which has been officially adopted in France in 2017 and subsequently by several countries. The network includes new authors (Egnell *et al.*, 2018; Egnell *et al.*, 2018b; Crosetto

et al., 2020; Julia *et al.*, 2017) and new contributions of authors already present in the past period, such as Julia (2017; 2018; 2020 in Sarda *et al.*, 2020).

One the first contributions in this timespan is given by Julia *et al.* (2018). In their research, authors state that the NS is a valid FOPL for increasing the chance of making salutary choice. Egnell *et al.* (2018) and Sarda *et al.* (2020), added that the NS outperforms other summary graded formats showing that it can rely on higher objective understanding. The NS label is one of the most simplified labels conveying consumers to a clearer and easier message (Talati *et al.*, 2019). The study conducted by Talati *et al.* (2019) states that the NS is the most effective FOPL in terms of consumer understanding. In addition, Egnell *et al.* (2018) demonstrated that FOPL nutrition labels had an important influence on the understanding of the healthiness of the products, and the NS led to a greater objective understanding relative to FOPL. While the study conducted by Crosetto *et al.* (2020) has demonstrated that simpler food label performs better than analytical and detailed food label. Julia *et al.* (2017) added that the NS, at this time, shows an increase in awareness due to communication, increasing presence in supermarkets and on the online platform.

The study conducted by Egnell *et al.* (2018; 2019) also confirms that the NS label, due to its summarized and graduated colour format, is effective than the label in encouraging students, the subjects of the research under review, to shop for food of higher nutritional quality.

Also, Egnell *et al.* (2020) showed that the summarized and graded format of the NS is favorably perceived and understood, regardless of the type of consumer.

Table 13. – Co-citation network 5 in terms of authors, articles, year, country of authors and citation

	Id	Authors	Articles	Year	Country of authors	Citation
2017-2020	*1*	Egnell, M., Ducrot, P., Touvier, M., Allès, B., Hercberg, S., Kesse-Guyot, E., & Julia, C.	Objective understanding of Nutri-Score Front- Of-Package nutrition label according to individual characteristics of subjects: Comparisons with other format labels	2018	France	91
	2	Egnell, M., Boutron, I., Péneau, S., Ducrot, P., Touvier, M., Galan, P., ... & Julia, C.	Front-of-Pack Labeling and the Nutritional Quality of Students' Food Purchases: A 3-Arm Randomized Controlled Trial	2019	France	26
	3	Egnell, M., Crosetto, P., D'almeida, T., Kesse-Guyot, E., Touvier, M., Ruffieux, B., ... & Julia, C.	Modelling the impact of different front-of- package nutrition labels on mortality from non-communicable chronic disease	2019	France	50
	4	Crosetto, P., Lacroix, A., Muller, L., & Ruffieux, B.	Nutritional and economic impact of five alternative front-of-pack nutritional labels: experimental evidence	2020	France	43

5	Talati, Z., Egnell, M., Hercberg, S., Julia, C., & Pettigrew, S.	Consumers' Perceptions of Five Front-of-Package Nutrition Labels: An Experimental Study Across 12 Countries	2020	France	49
6	Fialon, M., Egnell, M., Talati, Z., Galan, P., Dréano-Trécant, L., Touvier, M., ... & Julia, C.	Effectiveness of Different Front-of-Pack Nutrition Labels among Italian Consumers: Results from an Online Randomized Controlled Trial	2020	France	17
7	Dréano-Trécant, L., Egnell, M., Hercberg, S., Galan, P., Soudon, J., Fialon, M., ... & Julia, C.	Performance of the Front-of-Pack Nutrition Label Nutri-Score to Discriminate the Nutritional Quality of Foods Products: A Comparative Study across 8 European Countries	2020	France	39
8	Sarda, B., Julia, C., Serry, A. J., & Ducrot, P.	Appropriation of the Front-of-Pack Nutrition Label Nutri-Score across the French Population: Evolution of Awareness, Support, and Purchasing Behaviors between 2018 and 2019	2020	France	11

Table 14. – Relative strength of the nodes within the co-citation network 5

Node	Co-citation network	Betweenness	Closeness	PageRank
Julia C	3	23,0186	0,0149	0,0199
Egnell M	3	21,1437	0,0147	0,0198
Ducrot P	3	33,2542	0,0149	0,0199
Hersey JC	3	126,8358	0,0159	0,0203
Crosetto P	3	12,9291	0,0143	0,0196
Hawley KL	3	33,9948	0,0152	0,0200
Vyth EL	3	23,4873	0,0149	0,0196
Who	3	9,1579	0,0143	0,0196
Hercberg S	3	0,5694	0,0116	0,0189
Chantal J	3	10,0508	0,0143	0,0196
Adriouch S	3	0,0358	0,0106	0,0186
Rayner M	3	0,2922	0,0108	0,0186
Deschasaux M	3	0,0000	0,0101	0,0183
Donnenfeld M	3	0,0358	0,0106	0,0186
Dubois P	3	2,6335	0,0115	0,0189

Co-citation Network 6

Similarly, over this period of time, the European Union, within the recent "*Farm-to-Fork*" strategy initiated an attempt to harmonize FOPLs, while, at the same time, scholars started integrating the concept of FOPL harmonization in their work. In the last regulatory attempt, the EU, with the "*Inception Impact Assessment*", focused on finding a unifying solution by assessing the differential performance of FOPLs, such as the NS (already adopted in different countries), the NutrInform Battery (proposed by Italy), and the Keyhole (utilized by Sweden and other Scandinavian countries). As a consequence, several authors continued to conduct research about the other label and on label's understanding (Table 15). More precisely, Findling *et al.* (2018) carried out new research and added new contribution in this co-citation network.

Some relevant advancements have been proposed by Findling *et al.* (2018) who, drawing on studies of Roberto *et al.* (2012), stated that the presence of the FOPL definitely improved consumers' nutritional knowledge significantly. In this context, Stop Sign labels appear to be most effective in helping nutrient ratings, disease risk perceptions, brand attitudes and purchase

intentions by targeting high levels of negative nutrients (saturated fat, sodium). On the other hand, the same research states that the situation changes when looking at nutrient accuracy scores for a wider range of six nutrients. The study conducted by Findling *et al.* (2018), identified that different label preferences are noted in different situations. In the same study, the MTL allowed to better estimate the levels of nutrients than all other labels. Zhang *et al.* (2017) confirmed another very important issue regarding the choice of products according to demographic factors. In fact, this study confirmed what has been said in previous studies that different demographic characteristics lead to different uses of nutrition labels. For example, the current study shows that women pay much more attention to information on labels.

Considering that within 2022, the EU plans to define a final set of regulations to ensure a standardized front-of-pack nutrition labelling in Europe, a strong competition among the different proposals arose due to their ability to promote the consumption of some products while discouraging others. Indeed, it has been one of the main issue highlighted by local authorities in some country, to indicate how the implementation of some FOPL would drastically penalize the consumption of certain categories of products with serious effects on the industry. Consequently, some stream of research consolidated their position and other, such that of MTL, drastically reduced the scenario after the Brexit.

Table 15. – Co-citation network 6 in terms of authors, articles, year, country of authors and citation.

	Id	Authors	Articles	Year	Country of authors	Citation
2017-2022	1	Zhang, Y., Chen, J. T., Wang, S., Andrews, J. C., & Levy, A.	How Do Consumers Use Nutrition Labels on Food Products in the United States?	2017	USA	8
	2	Findling, M. T. G., Werth, P. M., Musicus, A. A., Bragg, M. A., Graham, D. J., Elbel, B., & Roberto, C. A	Comparing five front-of-pack nutrition labels' influence on consumers' perceptions and purchase intentions	2018	USA	75
	3	Menger-Ogle, A. D., & Graham, D. J.	The influence of front-of-package nutrition claims on food perceptions and purchase intentions among Nepali consumers	2018	USA	13
	4	Rybak, G., Burton, S., Johnson, A. M., & Berry, C.	Promoted claims on food product packaging: Comparing direct and indirect effects of processing and nutrient content claims	2021	USA	2
	5	Meijer, G. W., Detzel, P., Grunert, K. G., Robert, M. C., & Stancu, V.	Towards effective labelling of foods. An international perspective on safety and nutrition	2021	USA	3
	6	Andrews, J. C., Netemeyer, R., Burton, S., & Kees, J.	What consumers actually know: The role of objective nutrition knowledge in processing stop sign and traffic light front-of-pack nutrition labels	2021	USA	5

Emerging Co-citation Networks

In this last period, a new co-citation network emerged, as study of NS comparison to other labels. In addition, the issue of the importance of the use of FOPL as well as the relevance for policy makers of which labels to choose emerged. There comes a critical time for governments, different situations emerge, there are historical events that lead to changes. This situation brings about a decrease in the relevance of the NS, which had become one of the central labels.

The study conducted by Talati *et al.* (2018), highlights that FOPL may, even unconsciously, improve the quality of the chosen product. Another study, conducted by Talati *et al.* (2018b), tested consumer awareness of how it changes if the FOPL label is present. The study confirmed the importance of FOPL, stating that consumers are more aware of healthier choices when FOPL labels are displayed (2018b).

Pettigrew *et al.* (2018) confirms what Talati *et al.* (2018b) stated, asserting that interpretative FOPL labels help consumers to make healthier food choices more than non-interpretive ones as RIs (Fialon *et al.*, 2020; Kelly *et al.*, 2019). Therefore, Pettigrew *et al.* (2018) even confirmed previous studies that FOPL improve consumer awareness. Nevertheless, the performance of different labels changes depending on various factors, and color-coded in-formation with a summarizing graduated graphic design is the most effective element of the label. The study, conducted by Kelly *et al.* (2019), echoes the importance of product information and shredded light on the acceptance of FOPL.

In addition, Egnell *et al.* (2020) compared all types of FOPL, including the NS. The result of this study states that among all the different FOPL there are no significant differences affecting food choices and perceptions. Yet, the NS shows the best result in terms of ranking products according to nutritional quality.

In the same year, Fialon *et al.* (2020) confirmed that the presence of FOPL improves the perception of nutritional quality and confirmed that the NS is the best FOPL to highlight the nutritional quality of food .

1.5.2. Network Analysis

The analysis of network measures and community-driven measures, highlights a positive correlation between the betweenness centrality, closeness centrality, PageRank and H-index, indicating that those more central in the network have a higher likelihood to influence other authors. As showed in Table 16, the H-index is positively correlated to closeness centrality. It suggests that users with a shorter average distance to all other vertices in the network (i.e., close to the other nodes) are more influential and impactful. Similarly, those authors connected to the highest number of shortest path between two vertices are those who are more likely to control communication since several links are passing through those paths (Freeman, 2017). As regards, the PageRank index (Brin & Page, 1998) most connected authors (i.e., relevant nodes) are those with higher H-Index (Table 16).

Table 16. – Correlation analysis with network measures

Variable	Betweenness centrality	Closeness centrality	PageRank
Betweenness centrality			
Closeness centrality	0.47** (.34,.58)		
PageRank	0.47** (.35,.58)	0.55** (.44,.65)	
H-index	0.14** (.9,.19)	0.18** (.11,.23)	0.24** (.09,.37)

*=p<0.001; **= p<0.01; ***=p<0.05.

In line with correlation analysis, the Table 17 describe that, on average, the authors with the highest H-Index are those with higher levels of Betweenness and PageRank. As a result, network centrality mirrors the H-index, showing authors that gained a central position in their specific sub-networks. However, being the literature a ground for comparison, a higher centrality in the network does not imply incontrovertible findings.

Table 17. – Position of authors in the network and their measures. Authors in bold are those with a value above the mean.

Author	Betweenness	Closeness	PageRank	H_index
Julia c	5046,0840	0,00005709	0,0100	15
Hercberg s	2630,1252	0,00005682	0,0068	14
Talati z	2337,1708	0,00005735	0,0058	10
Pettigrew s	1917,2877	0,00005733	0,0024	10
Touvier m	152,3228	0,00005653	0,0013	10
Burton s	4048,7644	0,00005739	0,0089	8
Egnell m	2123,5205	0,00005680	0,0061	8
Mejean c	942,5946	0,00005687	0,0053	7
Dixon h	18,9825	0,00005692	0,0017	7
Kelly b	8436,2534	0,00005788	0,0053	6
Miller jc	0,0000	0,00004584	0,0009	6
Galan p	0,0000	0,00005628	0,0004	6
Ducrot p	3603,5131	0,00005722	0,0080	5
Howlett e	767,1588	0,00005673	0,0031	5
Newman cl	5421,8157	0,00005766	0,0035	4

Andrews jc	5074,1672	0,00005750	0,0113	3
Deschasaux m	90,0606	0,00005634	0,0014	3
Kees j	115,9491	0,00005656	0,0007	3
Hughes c	0,0000	0,00005524	0,0003	3

The results highlights how some authors are more linked than others and con-tribute, in terms of articles produced, to the same topics or fields, reinforcing mutual strength in the network, despite the variety of topics discussed. There is a high level of citations for network 1, which reflect the firsts contributions to the topic and it is naturally cited as foundation articles and, similarly, for co-citation network 3, which mainly reflects the contributions to the NS (Table 18).

Table 18. – Average Betweenness, closeness centrality and PageRank per co-citation network compared to the average mean of the network.

	Betweenness centrality (Avg)	**Closeness centrality (Avg)**	**PageRank (Avg)**
Mean of co-citation network 1	37,8750	0,0039	0,0234
Mean of co-citation network 2	22,0833	0,0040	0,0223
Mean of co-citation network 3	39,4106	0,0078	0,0190
Mean of co-citation network 4	28,8621	0,0067	0,0208
Mean of co-citation network 6	17,7916	0,0130	0,0203
Mean of co-citation network 5	19,8293	0,0132	0,0194
Mean of emerging co-citation netw.	9,6941	0,0126	0,0203
Overall Mean	*25,0780*	*0,0088*	*0,0208*

A relevant results which indicate the need to further investigate the structure of the literature and understand whether relevant gaps have been overlooked overtime. This network density might produce over-concentration of attention on main-stream topics, despite the presence of other alternative less convergent streams, of equal theoretical validity. The risk for policy-makers when assessing FOPL by leveraging only on an quantitative output-based approach is to overweight the implication merely deriving from the convergence on a topic, and to ignore underweighted results in the co-citation networks. However, the goal of the literature is to compare, contrast and upgrade scientific evidence through the comparison of different streams, especially when a multi-faceted nature of perspectives is present and an overall convergence on a sole topic does not exist.

In the second part of the analysis, to further assess the evolution of the networks and fulfil the existing gaps, we qualitative analysed and discussed the topics covered in the networks, and the positions of the authors within them.

1.5.3. What's next with most recent contributions

The NS oriented co-citation network mainly evolved in the last two decades be-coming more and more central. Conversely, the Co-citation network 2 significantly reduced its co-citation whereas the Co-citation network 3 partially increased. Co-citation network 3 did not exist in the 1989-2011 timespan while drastically increased the share of co-citation during 2012-2016 period and consolidate it in the last analysed period (2017- 2020). The other co-citation networks, such as have lost several ties indicating the lack of temporariness of the links.

This stage of the research showed that relevant components exist and evolved within the broader network over time. Authors within the main network are englobed in co-citation's subgroups, sometime driven by similar country of affiliation, that evolved in the three analysed periods. Some co-citation's subgroups did not show strong ties and the members disappear from the network, due to a reduced number of articles produced, in the analysed timespan or tend to be absorbed by more consolidated subgroups. The NS oriented co-citation network firstly appeared in the 2011-2016 timespan and consolidate itself during 2017-2020 period increasing the number of published articles, the number of co-citations and the number of studies about the NS.

More recent contributions continue to highlight the relevance of FOPL and their positive effects on consumers' choices. However, there is still a multitude of valid effects demonstrated without a full convergence of the authors: several studies pointed out the superiority specifically of NS, followed by Multiple Traffic Lights and Simplified Food Labelling System; on the other hand, studies which criticize the NS have emerged, particularly regarding the absence of vitamins/minerals and sustainability/environmental impact measures from the scoring algorithm.

1.6. Discussion

This research is one of the first bibliometric analysis corroborated by a systematic literature review on the increasingly relevant topic of FOPL over a time period ranging from 1989-2020 and on 170 articles. The evidence arising from the analysis mainly refer to the evolution of policy-making initiatives, FOPL theory and their interrelations.

The regulation flow evolved in the last decades observing the consumer with different lenses. In 1990, emanated the Council Directive 90/496/EEC respecting a paradigm which consider the information able to guide individuals in their rational decision-making process. In this period, the nutrition labelling systems are considered item to support the decision and not to nudge it toward healthier choices . Contemporarily, the literature has studied the effects of the nutrition labelling systems and FOPL, mainly arriving to non- univocal results and suggesting relevant implications to improve the effectiveness of this tool.

Indeed, in 2008, with the new Proposal, the EU Commission suggested new implementations for FOPL which are able to orientate consumers' decisions. A shift in the paradigm which mainly arose from the increasing level of obesity in Europe and the recognition of the bounded rationality of individuals and factors affecting the decisions (Simon, 1954).

A new way to conceive FOPL and their roles in consumer decision-making process which led to the Regulation (EU) 1169/2011 and the mandatory application of nutrition information on packaging. In this evolutionary stage, regulators wanted to make FOPL mandatory and, in addition, easy to understand for the average consumer. In contraposition with the "*information paradigm*", the Regulation (EU) 1169/2011 laid down the ground for a strong competition among the different proposals in EU.

Since the obligations provided by the regulation 1169/2011 became mandatory in 2016, some European proposals started to form their contributions beforehand and consolidated their position in the subsequent years. In fact, the period between 2011 and 2020 welcomed new FOPL proposed by Member States and several studies about these new concepts appeared even before their launch in the market. For instance, studies on NS mainly appeared from 2013 and the FOPL has been launched in 2017.

In this test-phase, the literature assessed the effectiveness and the effects on new proposals but, as for the previous timespan, mainly arriving to opposite results. In this uncertain context, the main difference able to characterize the strength of the studies is the existence of a network to support the evidence. However, although some networks appear more consolidated in the literature, as for the co-citation network 3, focused on NS, and others more fragmented, policy-makers should clearly recognize that the degree of support toward an evidence does not imply the non-validity of other – as important as – evidences. It appears confirmed by studies

indicating different FOPL performances for *subjective understanding* (Hersey *et al.*, 2013; de la Cruz-Gòngora, 2017) and *objective understanding* (Ducrot *et al.*, 2015; Egnell *et al.*, 2018; Egnell *et al.*, 2020). Part of previous literature utilized the conceptual framework developed by Grunert and Wills (2007), focusing on consumers' objective and subjective under-standing, and leading to controvertible evidence of an absolute superiority of a specific FOPL capable of affecting consumer behaviour toward healthier lifestyles.

However, in periods 2012-2016 and 2017-2020 appears only one co-citation network, indicating a reinforced convergence across the topics discussed. In this stream, authors mainly evidence the results of the NS label and its different effects in affecting consumers' choices. In this coherent evolution, the network increased the level of internal citations even reinforcing the number of articles produced over the years. The majority of them, as exposed before, converge on the same topic and form a separate stream of research in relation to the others. Moreover, as seen through the correlation analysis, by increasing the number of co-citation, there is a back-forward propagation effect which lead articles to increase their centrality in the network.

Nevertheless, more than the half of the literature appears oriented to other results even if more fragmented and not consolidated in a common stream of research. The other co-citation networks temporary converges on same topics or findings in the limits of the analysed timeframe and tend to completely disappear or redistributed in the other networks along the entire time horizon. These other components of the literature mainly investigate other label types and their effects. Other investigations, as for the co-citation networks 1 and 4, mainly focused on the understanding the factors the drive the comprehension of FOPL and the differences related to socio-demographics characteristics. On the other hand, the co-citation network 2 and 3 are more oriented towards the antecedent of the usage of FOPL. Similarly, additional contributions dared to explored untapped avenues, created the basis for alternative frameworks or point of view, developing alternative and complementary conceptual frameworks to help consumers' decision-making toward utilization and acceptance of FOPLs that support informed decisions toward healthier diets.

1.7. Open points and research directions

The most recent goal of EU policy-makers is to find an harmonized and universal labelling system to adapt in the European Community. However, observing the structure of extant literature there might be two current risks that should be avoided. The first risk is to outline a labelling scheme which is not fully supported by converging evidences as derived from multiple different constructs. The second one refers to the risk to implement a labelling scheme grounded on valid results and on high levels of citations, supported by a network of authors, but overlooking the fragmentation of other valid positions in the literature that together contribute to depict an environment in which the different and still valid results reflect the diversity of alternatives that are equally effective, but less supported. In conclusion, the right choice of FOPL would benefit both consumers and the food industry but, there are still additional knowledge and usage gaps that must be fulfilled to define the proper universal option that support consumers toward healthier and more informed food choices.

Results from extant literature shows that FOPLs seem to be generally appreciated by consumers, perceived as helping in their process of choosing food products and preferred over the generic labels conventionally present on the back of the packaging. However, the process that leads to the actual choice of the product is complex and is articulated according to some well-defined phases. FOPL are useful as they help the consumer to move through the decision-making process in an informed, rapid and effective way; but their effectiveness varies due to numerous variables, including those attributable to the type of labeling. In fact, considering the selective attention of customers, the little time available that they have during the choice process, the extreme variety of stimuli that surround them at the time of purchase and their tendency to evaluate others elements such as the price or the brand of the product, FOPLs must be carefully designed to help a vast and non-homogeneous set of consumers to make balanced choices for their health.

The challenge is that the structure of the FOPL must, on the one hand, be easy and immediate to understand and, on the other hand, it must be explanatory and complete with all the information necessary to be able to make an informed choice. In fact, if on the one hand some labels, making use of algorithms, are extremely summarizing and explanatory at the expense of detailed information and not taking into consideration important characteristics such as frequency of consumption and quantity, on the other hand, more informative labels may

sometimes be difficult to understand, as they do not have explanatory graphics and help to purchase in a limited period of time or even compressed. This trade-off between analytical information and simplicity aimed at immediate understanding, as well as an extreme variety of labels on the market, generated the need, at EU level in its "*From Farm-to-Fork*" strategy, to identify a FOPL that is effective and better at all stages of the decision-making process and can therefore be taken as a reference.

In this context, the current situation highlights the presence of many under-researched area such as those that behaviourally assess the acceptance of FOPLs, with the need of new research streams that can contribute to the debate on which type of label (Summary vs. Nutrient-Specific) could better lead consumers in improving their food choices

Among the critical questions that remain open, a core one it is the clarification of the impact in consumers' decision-making, of the two complementary paths of *understanding* - *objective* and *subjective* - and of *liking* of the information reported on the label. Until now, most of the studies have focused purely on the *objective* side, showing a good performance of the Summary labels. This component proven to be important as it allows to verify the consumer's ability to correctly interpret what FOPLs intend to convey. However, it is considered equally relevant in the process to explore the *subjective* component, that complement FOPL comprehensibility. Both elements are, in fact, essential for the assessment of the effects of FOPL on the *understanding* of information.

Further, it is of interest to test whether relevant differences in terms of *usefulness* and *ease of use* occur when comparing consumers' *acceptance* of different FOPLs, a currently under-researched area, all in conjunction with the potential role of moderators such as the trust in this process.

In synthesis, in recent years, increasing attention to the utilisation of Front-Of-Pack nutritional Labels as a tool to prompt individuals towards healthier and more informed food choices has been observed both in regulatory bodies and academic research. However, few theoretical models have been used to understand their role in consumer decision-making, as well as the antecedents that induce individuals to accept the information provided by the label, and to benchmark FOPL performance in different markets.

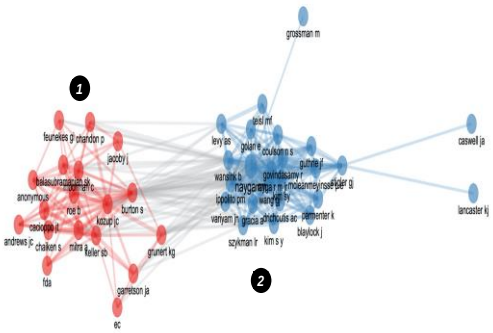
The objective of this research is then to understand how different systems of Front-of-Pack nutritional Labels affect consumers' decision-making processes toward healthier and more informed food choices, also as input for the ongoing policy-making discussions at EU level.

This research aims then at increasing the knowledge about the performance of different FOPLs on several dimensions of food decision-making, in way that theoretical and managerial implications could be used as a valid support to managers and policy-makers in their decision toward a unified label at European level.

The proposed research provide a relevant contribution both for a relevant topic in the current international policy discussion as well as an add-on on marketing theory with a better understanding on how policy-based stimuli might be effective in creating a truly informed decision-making, also opening future stream of research.

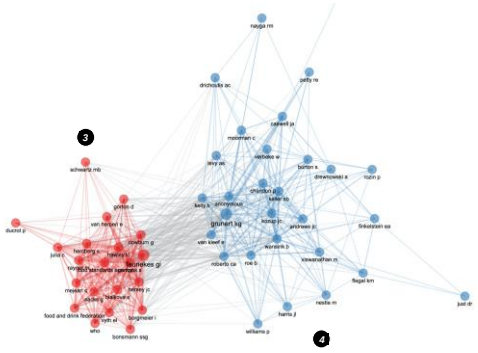
1.8. Supplementary Materials: graphical representation of co-citation networks

S1: 1989-2011 period



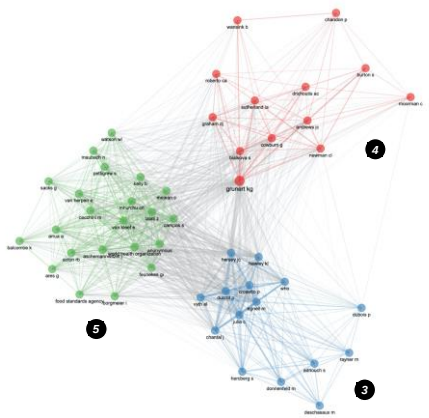
1989-2011: Discovering the relevance of nutrition-related information.

S2: 2012 – 2016 period



2012 – 2016 - The drivers of acceptance of Front-of-Pack labels.

S3: 2017 – 2022 period



Period: 2017 – 2022 – Opening up to alternatives and challenging the mainstream.

References

Andrews, J.C.; Netemeyer, R.G.; Burton, S. (1998). Consumer generalization of nutrient content claims in advertising. *J. Mark.* 1998, 62, 62–75.

Andrews, J.C.; Burton, S.; Netemeyer, R.G. (2000). Are Some Comparative Nutrition Claims Misleading? The Role of Nutrition Knowledge, Ad Claim Type and Disclosure Conditions. *J. Advert.* 2000, 29, 29–42. https://doi.org/10.1080/00913367.2000.10673615.

Andrews, J.C.; Burton, S.; Kees, J. (2011). Is Simpler Always Better? Consumer Evaluations of Front-of-Package Nutrition Symbols. *J. Public Policy Mark.* 2011, 30, 175–190. https://doi.org/10.1509/jppm.30.2.175.

Andrews, J.C.; Lin, C.-T.J.; Levy, A.S.; Lo, S. (2014). Consumer Research Needs from the Food and Drug Administration on Front-of-Package Nutritional Labeling. *J. Public Policy Mark.* 2014, 33, 10–16. https://doi.org/10.1509/jppm.33.1.10.

Aschemann-Witzel, J.; Grunert, K.G.; van Trijp, H.C.; Bialkova, S.; Raats, M.; Hodgkins, C.; Wąsowicz, G.; Koenigstorfer, C.(2013). J. Effects of nutrition label format and product assortment on the healthfulness of food choice. *Appetite* 2013, 71, 63–74. https://doi.org/10.1016/j.appet.2013.07.004.

Barreiro-Hurlé, J.; Gracia, A.; De-Magistris, T. (2010). Does nutrition information on food products lead to healthier food choices? *Food Policy* 2010, 35, 221–229. https://doi.org/10.1016/j.foodpol.2009.12.006.

Bavelas, A. Communication patterns in task-oriented groups (1950). J. *Acoust. Soc. Am.* 1950, 22, 725–730.

Beauchamp, M.A. (1995). An improved index of centrality *Syst. Res. Behav. Sci.* 1965, 10, 161–163. https://doi.org/10.1002/bs.3830100205.

Becker, M., & Rasmussen, I. (2008). Guidance of attention to objects and locations by long-term memory of natural scenes. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 35(6):1325–1338.

Becker, M. W., Bello, N. M., Sundar, R. P., Peltier, C., & Bix, L. (2015). Front-of-pack labels enhance attention to nutrition information in novel and commercial brands. *Food Policy 56*, 76–86.

Benckendorff, P.; Zehrer, A. (2013). A Network Analysis of Tourism Research. *Ann. Tour. Res.* 2013, 43, 121–149. https://doi.org/10.1016/j.annals.2013.04.005.

Bichteler, J.; Eaton, E.A., III (1980). The combined use of bibliographic coupling and co-citation for document retrieval. J. *Am. Soc. Inf. Sci.* 1980, 31, 278–282.

Bonsmann, S.S.G.; Celemín, L.F.; Grunert, K.G.; on behalf of the FLABEL consortium Food Labelling to Advance Better Education for Life (2010). *Eur. J. Clin. Nutr.* 2010, 64, S14–S19. https://doi.org/10.1038/ejcn.2010.204.

Blondel, V.D.; Guillaume, J.L.; Lambiotte, R.; Lefebvre, E. (2008). Fast unfolding of communities in large networks. *J. Stat. Mech. Theory Exp.* 2008, 2008, P10008.

Braam, R.R.; Moed, H.F.; van Raan, A.F. (1991) Mapping of science by combined co-citation and word analysis. I. Structural aspects. J. Am. Soc. Inf. Sci. 1991, 42, 233–251.

Brin, S.; Page, L. (1998). The anatomy of a large-scale hypertextual Web search engine *Comput. Netw.* ISDN Syst. 1998, 30, 107–117. https://doi.org/10.1016/s0169-7552(98)00110-x.

Burton, S.; Biswas, A.; Netemeyer, R. (1994). Effects of Alternative Nutrition Label Formats and Nutrition Reference Information on Consumer Perceptions, Comprehension, and Product Evaluations. *J. Public Policy Mark.* 1994, 13, 36–47. https://doi.org/10.1177/074391569401300103.

Burton, S.; Andrews, J.C. (1996). Age, Product Nutrition, and Label Format Effects on Consumer Perceptions and Product Evaluations. J. *Consum. Aff.* 1996, 30, 68–89. https://doi.org/10.1111/j.1745-6606.1996.tb00726.x.

Burton, S.; Garretson, J.A.; Velliquette, A.M. (1999). Implications of Accurate Usage of Nutrition Facts Panel Information for Food Product Evaluations and Purchase Intentions. *J. Acad. Mark. Sci.* 1999, 27, 470–480. https://doi.org/10.1177/0092070399274006.

Caswell, J.A.; Padberg, D.I. (1992). Toward a More Comprehensive Theory of Food Labels. *Am. J. Agric. Econ.* 1992, 74, 460–468. https://doi.org/10.2307/1242500.

Croker, H.; Packer, J.; Russell, S.J.; Stansfield, C.; Viner, R.M. (2020). Front of pack nutritional labelling schemes: A systematic review and meta-analysis of recent evidence relating to objectively measured consumption and purchasing. *J. Hum. Nutr. Diet.* 2020, 33, 518–537. https://doi.org/10.1111/jhn.12758.

Crosetto, P.; Lacroix, A.; Muller, L.; Ruffieux, B. (2020) Nutritional and economic impact of five alternative front-of-pack nutritional labels: Experimental evidence. *Eur. Rev. Agric. Econ.* 2020, 47, 785–818. https://doi.org/10.1093/erae/jbz037.

Council Directive 90/496/EC (1990). Direttiva 90/496/CEE del Consiglio, del 24 Settembre 1990, Relativa All'Etichettatura Nutrizionale dei Prodotti Alimentari. Available online: https://eur-lex.europa.eu/legal-content/IT/ALL/?uri=CELEX%3A31990L0496 (accessed on April 21st, 2022).

de la Cruz-Góngora, V.; Torres, P.; Contreras-Manzano, A.; de la Mota, A.J.; Mundo-Rosas, V.; Villalpando, S.; Rodríguez-Oliveros, G. (2017). Understanding and acceptability by Hispanic consumers of four front-of-pack food labels. *Int. J. Behav. Nutr. Phys. Act.* 2017, 14, 28. https://doi.org/10.1186/s12966-017-0482-2.

DeJoy, D. (1991). A Revised Model of the Warnings Process Derived from Value-Expectancy Theory. *Human Factors Society 22nd Annual Meeting. CA Human Factors Society.* Santa Monica

Ding, Y.; Chowdhury, G.G.; Foo, S. (2001). Bibliometric cartography of information retrieval research by using co-word analysis. *Inf. Process. Manag.* 2001, 37, 817–842. https://doi.org/10.1016/s0306-4573(00)00051-0.

Drichoutis, A.; Lazaridis, P.; Nayga, R.M. (2005). Nutrition knowledge and consumer use of nutritional food labels. *Eur. Rev. Agric. Econ.* 2005, 32, 93–118. https://doi.org/10.1093/erae/jbi003.

Ducrot, P.; Méjean, C.; Julia, C.; Kesse-Guyot, E.; Touvier, M.; Fezeu, L.K.; Hercberg, S.; Péneau, S. (2015). Objective Understanding of Front-of-Package Nutrition Labels among Nutritionally At-Risk Individuals. *Nutrients* 2015, 7, 7106–7125. https://doi.org/10.3390/nu7085325.

Ducrot, P.; Julia, C.; Méjean, C.; Kesse-Guyot, E.; Touvier, M.; Fezeu, L.K.; Hercberg, S.; Péneau, S. (2016). Impact of Different Front-of-Pack Nutrition Labels on Consumer Purchasing Intentions. *Am. J. Prev. Med.* 2016, 50, 627–636.

El Majjodi, A.; Starke, A.D.; Trattner, C. (2022). Nudging Towards Health? Examining the Merits of Nutrition Labels and Personalization in a Recipe Recommender System. In Proceedings of the UMAP'22 the 30th ACM Conference on User Modeling, Adaptation and Personalization, Barcelona, Spain, 4–7 July 2022; 1, 48–56. https://doi.org/10.1145/3503252.3531312.

Elshiewy, O.; Boztug, Y. (2018). When Back of Pack Meets Front of Pack: How Salient and Simplified Nutrition Labels Affect Food Sales in Supermarkets. *J. Public Policy Mark.* 2018, 37, 55–67. https://doi.org/10.1509/jppm.16.100.

Egnell, M.; Ducrot, P.; Touvier, M.; Allès, B.; Hercberg, S.; Kesse-Guyot, E.; Julia, C. (2018a). Objective understanding of Nutri-Score Front-Of-Package nutrition label according to individual characteristics of subjects: Comparisons with other format labels. *PLoS ONE* 2018, 13, e0202095. https://doi.org/10.1371/journal.pone.0202095.

Egnell, M.; Talati, Z.; Hercberg, S.; Pettigrew, S.; Julia, C. (2018b). Objective Understanding of Front-of-Package Nutrition Labels: An International Comparative Experimental Study across 12 Countries. *Nutrient* 2018, 10, 1542. https://doi.org/10.3390/nu10101542.

Egnell, M.; Crosetto, P.; D'Almeida, T.; Kesse-Guyot, E.; Touvier, M.; Ruffieux, B.; Hercberg, S.; Muller, L.; Julia, C. (2019a). Model-ling the impact of different front-of-package nutrition labels on mortality from non-communicable chronic disease. *Int. J. Behav. Nutr. Phys. Act.* 2019, 16, 56. https://doi.org/10.1186/s12966-019-0817-2.

Egnell, M.; Boutron, I.; Péneau, S.; Ducrot, P.; Touvier, M.; Galan, P.; Buscail, C.; Porcher, R.; Ravaud, P.; Hercberg, S. (2019b). Front-of-pack labeling and the nutritional quality of students' food purchases: A 3-arm randomized controlled trial. *Am. J. Public Health* 2019, 109, 1122–1129.

Egnell, M.; Talati, Z.; Galan, P.; Andreeva, V.A.; Vandevijvere, S.; Gombaud, M.; Dréano-Trécant, L.; Hercberg, S.; Pettigrew, S.; Julia, C. (2020). Objective understanding of the Nutri-score front-of-pack label by European consumers and its effect on food choices: an online experimental study. *Int. J. Behav. Nutr. Phys. Act.* 2020, 17, 146.

EU Commission. Regulation (EU) No. 1169/2011 of the European Parliament and of the Council of 25 October 2011 on the Provision of Food Information to Consumers, Amending Regulations (EC) No. 1924/2006 and (EC) No. 1925/2006 of the European Parliament and of the Council, and Repealing Commission Directive 87/250/EEC, Council Directive 90/496/EEC, Commission Directive 1999/10/EC, Directive 2000/13/EC of the European Parliament and of the Council, Commission Di-rectives 2002/67/EC and 2008/5/EC and Commission Regulation (EC) No. 608/2004 Text with EEA Relevance. 2011. Available online: https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX%3A32011R1169 (accessed on April 24th, 2022).

EU Commission. EU Commission (2021b)—Inception Impact Assessment. Food Labelling—Revision of Rules on Information Provided to Consumers. 2021. Available online: https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12749-Food-labelling-revision-of-rules-on-information-provided-to-consumers_en (accessed on April 21st, 2022).

EU Commission 2020. Proposal for a Revision of Regulation (EU) No. 1169/2011 on the Provision of Food Information to Con-sumers. Available online: https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12749-Food-labelling-revision-of-rules-on-information-provided-to-consumers_en (accessed on April 24th, 2022).

EU Commission (2021b)—Inception Impact Assessment. Revision of the two Block Exemption Regulations for Horizontal Cooperation Agreements and the Horizontal Guidelines.

Available online: https://competition-policy.ec.europa.eu/public-consultations/2019-hbers_en (accessed on April 24th, 2022).

European Court of Justice. Urteil des Gerichtshofes (Fünfte Kammer) Vom 16 July 1998. Gut Springenheide GmbH und Rudolf Tusky gegen Oberkreisdirektor des Kreises Steinfurt—Amt für Lebensmittelüberwachung. Ersuchen um Vorabent-scheidung: Bundesverwaltungsgericht—Deutschland. Vermarktungsnormen für Eier—Werbewirksame Angaben, die ge-eignet sind, den Käufer irrezuführen—Referenzverbraucher. Rechtssache C-210/96. 1998. Available online: https://eur-lex.europa.eu/legal-content/DE/ALL/?uri=CELEX%3A61996CJ0210 (accessed on April 24th, 2022).

European Union. Council Directive 90/496/EEC of 24 September 1990 on Nutrition Labelling for Foodstuffs, OJ L 276; 6 October 1990; European Union: Brussels, Belgium, 1990; pp 40–44, Article 2.

Fialon, M.; Egnell, M.; Talati, Z.; Galan, P.; Dréano-Trécant, L.; Touvier, M.; Pettigrew, S.; Hercberg, S.; Julia, C. (2020). Effectiveness of Different Front-of-Pack Nutrition Labels among Italian Consumers: Results from an Online Randomized Controlled Trial. *Nutrients* 2020, 12, 2307. https://doi.org/10.3390/nu12082307.

Freeman, L.C. (2018) Research Methods in Social Network Analysis; Routledge: Abingdon, UK, 2017.Findling, M.T.G.

Goiana-da-Silva, F., Cruz-e-Silva, D., Miraldo, M., Calhau, C., Bento, A., Cruz, D., ... & Araújo, F. (2019). Front-of-pack la-belling policies and the need for guidance. *The Lancet Public Health*, 4(1), e15.

Gomes, S.; Nogueira, M.; Ferreira, M.; Gregório, M.J. (2017), Portuguese Consumers' Attitudes towards Food Labelling; WHO: Copenhagen, Denmark, 2017.

Gracia, A.; Loureiro, M.L.; Nayga, R.M., Jr. (2009). Consumers' valuation of nutritional information: A choice experiment study. *Food Qual. Prefer.* 2009, 20, 463–471.

Grunert, K.G.; Wills, J.M. (2007). A review of European research on consumer response to nutrition information on food labels. *J. Public Health* 2007, 15, 385–399. https://doi.org/10.1007/s10389-007-0101-9.

Grunert, K.G.; Fernández-Celemín, L.; Wills, J.M.; Storcksdieck Genannt Bonsmann, S.; Nureeva, L. (2010). Use and understanding of nutrition information on food labels in six European countries. *J. Public Health* 2010, 18, 261–277.

Grunert, K.G.; Hieke, S.; Wills, J. (2014). Sustainability labels on food products: Consumer motivation, understanding and use. *Food Policy* 2014, 44, 177–189. https://doi.org/10.1016/j.foodpol.2013.12.001.

Grunert, K.G.; Aachmann, K. (2016). Consumer reactions to the use of EU quality labels on food products: A review of the literature. *Food Control* 2016, 59, 178–187. https://doi.org/10.1016/j.foodcont.2015.05.021.

Hagenmeyer, M. (2008). The regulation overkill: Food information. New labelling and nutrition information legislation to follow the Claims Regulation. *Eur. Food Feed Law Rev.* 2008, 26, 165-178.

Hawley, K.L.; A Roberto, C.; Bragg, M.; Liu, P.; Schwartz, M.B.; Brownell, K.D. (2013). The science on front-of-package food labels. *Public Health Nutr.* 2013, 16, 430–439. https://doi.org/10.1017/s1368980012000754.

Hersey, J.C.; Wohlgenant, K.C.; Arsenault, J.E.; Kosa, K.M.; Muth, M.K. (2013). Effects of front-of-package and shelf nutrition labeling systems on consumers. *Nutr. Rev.* 2013, 71, 1–14. https://doi.org/10.1111/nure.12000.

Hodgkins, C.; Barnett, J.; Wasowicz-Kirylo, G.; Stysko-Kunkowska, M.; Gulcan, Y.; Kustepeli, Y.; Akgungor, S.; Chrysso-choidis, G.; Fernández-Celemin, L.; Bonsmann, S.S.G. (2012). Understanding how consumers categorise nutritional labels: A consumer derived typology for front-of-pack nutrition labelling. *Appetite* 2012, 59, 806–817.

Ikonen, I.; Sotgiu, F.; Aydinli, A.; Verlegh, P.W. (2020). Consumer effects of front-of-package nutrition labeling: An interdisciplinary meta-analysis. *J. Acad. Mark. Sci.* 2020, 48, 360–383.

Ippolito, P.M.; Mathios, A.D. (1993). New Food Labeling Regulations and the Flow of Nutrition Information to Consumers. *J. Public Policy Mark.* 1993, 12, 188–205. https://doi.org/10.1177/074391569101200205.

Izquierdo, L.R.; Hanneman, R.A. (2006). Introduction to the Formal Analysis of Social Networks Using Mathematica; University of California, Riverside: Riverside, CA, USA, 2006.

Hodgkins, C.E.; Raats, M.M.; Fife-Schaw, C.; Peacock, M.; Gröppel-Klein, A.; Koenigstorfer, J.; Wasowicz, G.; Stysko-Kunkowska, M.; Gulcan, Y.; Kustepeli, Y. (2015). Guiding healthier food choice: Systematic comparison of four front-of-pack labelling systems and their effect on judgements of product healthiness. *Br. J. Nutr.* 2015, 113, 1652–1663. https://doi.org/10.1017/s0007114515000264.

Jones, A.; Neal, B.; Reeve, B.; Mhurchu, C.N.; Thow, A.M. (2019). Front-of-pack nutrition labelling to promote healthier diets: Current practice and opportunities to strengthen regulation worldwide. *BMJ Glob. Health* 2019, 4, e001882. https://doi.org/10.1136/bmjgh-2019-001882.

Julia, C.; Ducrot, P.; Péneau, S.; Deschamps, V.; Méjean, C.; Fézeu, L.; Touvier, M.; Hercberg, S.; Kesse-Guyot, E. (2015a). Discriminating nutritional quality of foods using the 5-Color nutrition label in the French food market: Consistency with nutritional recommendations. *Nutr. J.* 2015, 14, 100. https://doi.org/10.1186/s12937-015-0090-4.

Julia, C.; Kesse-Guyot, E.; Ducrot, P.; Péneau, S.; Touvier, M.; Méjean, C.; Hercberg, S.; Julia, C.; Kesse-Guyot, E.; Ducrot, P. (2015b). Performance of a Five Category Front-of-Pack Labelling System—The 5-colour nutrition label—To Differentiate Nutritional Quality of Breakfast Cereals in France. *BMC Public Health* 2015, 15, 179.

Julia, C.; Blanchet, O.; Méjean, C.; Péneau, S.; Ducrot, P.; Allès, B.; Fezeu, L.K.; Touvier, M.; Kesse-Guyot, E.; Singler, E. (2016). Impact of the front-of-pack 5-colour nutrition label (5-CNL) on the nutritional quality of purchases: An experimental study. *Int. J. Behav. Nutr. Phys. Act.* 2016, 13, 1–9. https://doi.org/10.1186/s12966-016-0416-4.

Julia, C.; Hercberg, S. (2017a). Nutri-Score: Evidence of the effectiveness of the French front-of-pack nutrition label. *Ernahr. Umsch.* 2017, 64, 181–187. https://doi.org/10.4455/EU.2017.048.

Julia, C.; Péneau, S.; Buscail, C.; Gonzalez, R.; Touvier, M.; Hercberg, S.; Kesse-Guyot, E. (2017b). Perception of different formats of front-of-pack nutrition labels according to sociodemographic, lifestyle and dietary factors in a French population: Cross-sectional study among the NutriNet-Santé cohort participants. *BMJ Open* 2017, 7, e016108.

Julia, C.; Martinez, L.; Allès, B.; Touvier, M.; Hercberg, S.; Méjean, C.; Kesse-Guyot, E. (2018). Contribution of ultra-processed foods in the diet of adults from the French NutriNet-Santé study. *Public Health Nutr.* 2018, 21, 27–37.

Kelly, B.; Jewell, J. (2019). Front-of-pack nutrition labelling in the European region: Identifying what works for governments and consumers. *Public Health Nutr.* 2019, 22, 1125–1128. https://doi.org/10.1017/s1368980018003737.

Keller, S.B.; Landry, M.; Olson, J.; Velliquette, A.M.; Burton, S.; Andrews, J.C. (1997). The Effects of Nutrition Package Claims, Nutrition Facts Panels, and Motivation to Process Nutrition Information on Consumer Product Evaluations. J. *Public Policy Mark.* 1997, 16, 256–269. https://doi.org/10.1177/074391569701600206.

Kim, J.; McMillan, S. (2008). Evaluation of Internet Advertising Research: A Bibliometric Analysis of Citations from Key Sources. *J. Advert.* 2008, 37, 99–112. https://doi.org/10.2753/joa0091-3367370108.

Kleef, E.V.; Dagevos, H. (2015). The growing role of front-of-pack nutrition profile labeling: A consumer perspective on key issues and controversies. *Crit. Rev. Food Sci. Nutr.* 2015, 55, 291–303.

Köseoglu, M.A.; Sehitoglu, Y.; Craft, J. (2105). Academic foundations of hospitality management research with an emerging country focus: A citation and co-citation analysis. *Int. J. Hosp. Manag*. 2015, 45, 130–144. https://doi.org/10.1016/j.ijhm.2014.12.004.

Latino, M.E.; Menegoli, M.; Corallo, A. (2109). Food Label Design—Exploring the Literature. *Br. Food J.* 2019, 122, 766–778.

Lee WC, J.; Shimizu, M.; Kniffin, K.M.; Wansink, B. (2013). You taste what you see: Do organic labels bias taste perceptions? *Food Qual. Prefer.* 2013, 29, 33–39.

Levy, A.S.; Fein, S.B.; Schucker, R.E. (1996). Performance Characteristics of Seven Nutrition Label Formats. *J. Public Policy Mark.* 1996, 15, 1–15. https://doi.org/10.1177/074391569601500101.

Levy, A.S.; Fein, S.B. (1998). Consumers' Ability to Perform Tasks Using Nutrition Labels. *J. Nutr. Educ.* 1998, 30, 210–217. https://doi.org/10.1016/s0022-3182(98)70321-8.

Liu, P.J.; Roberto, C.A.; Liu, L.J.; Brownell, K.D. (2012). A test of different menu labeling presentations. *Appetite* 2012, 59, 770–777. https://doi.org/10.1016/j.appet.2012.08.011.

Loureiro, M.L.; Gracia, A.; Nayga, R.M., Jr. (2006). Do consumers value nutritional labels? *Eur. Rev. Agric. Econ.* 2006, 33, 249–268.

Méjean, C.; Macouillard, P.; Péneau, S.; Hercberg, S.; Castetbon, K. (2013a). Consumer acceptability and understanding of front-of-pack nutrition labels. *J. Hum. Nutr. Diet.* 2013, 26, 494–503. https://doi.org/10.1111/jhn.12039.

Méjean, C.; Macouillard, P.; Péneau, S.; Hercberg, S.; Castetbon, K. (2013b). Perception of front-of-pack labels according to social characteristics, nutritional knowledge and food purchasing habits. *Public Health Nutr.* 2013, 16, 392–402. https://doi.org/10.1017/s1368980012003515.

Mialon, M.; Julia, C.; Hercberg, S. (2018). The policy dystopia model adapted to the food industry: The example of the Nutri-Score saga in France. *World Nutr.* 2018, 9, 109–120.

Mitra, A.; Hastak, M.; Ford, G.T.; Ringold, D.J. (1999). Can the Educationally Disadvantaged Interpret the FDA-Mandated Nutrition Facts Panel in the Presence of an Implied Health Claim? *J. Public Policy Mark.* 1999, 18, 106–117. https://doi.org/10.1177/074391569901800111.

Pádua, I.; Moreira, A.; Moreira, P.; de Vasconcelos, F.M.; Barros, R. (2019). Impact of the Regulation (EU) 1169/2011: Aller-gen-Related Recalls in the Rapid Alert System for Food and Feed (RASFF) Portal. *Food Control* 2019, 98, 389–398.

Pasadeos, Y.; Phelps, J.; Kim, B.-H. (1998). Disciplinary Impact of Advertising Scholars: Temporal Comparisons of Influential Authors, Works and Research Networks. *J. Advert.* 1998, 27, 53–70. https://doi.org/10.1080/00913367.1998.10673569.

Pettigrew, S.; Talati, Z.; Henriques, I.; Morley, B.; Ball, K. (2018). Characteristics of healthy weight advertisements in three countries. Aust. New Zealand *J. Public Health* 2018, 42, 27–29. https://doi.org/10.1111/1753-6405.12745

Roberto, C.A.; Bragg, M.A.; Seamans, M.J.; Mechulan, R.L.; Novak, N.; Brownell, K.D. (2012a). Peer reviewed: Evaluation of consumer understanding of different front-of-package nutrition labels, 2010–2011. *Prev. Chronic Dis.* 2012, 9, E149.

Roberto, C.A.; Bragg, M.A.; Livingston, K.A.; Harris, J.L.; Thompson, J.M.; Seamans, M.J.; Brownell, K.D. (2012b). Choosing front-of-package food labelling nutritional criteria: How smart were 'Smart Choices'? *Public Health Nutr.* 2012, 15, 262–267. https://doi.org/10.1017/s1368980011000826.

Roberto, C.A.; Khandpur, N. (2014). Improving the design of nutrition labels to promote healthier food choices and reasonable portion sizes. *Int. J. Obes.* 2014, 38, S25–S33

Roe, B.; Levy, A.S.; Derby, B.M. (1999). The Impact of Health Claims on Consumer Search and Product Evaluation Outcomes: Results from FDA Experimental Data. *J. Public Policy Mark.* 1999, 18, 89–105. https://doi.org/10.1177/074391569901800110.

Sarda, B.; Julia, C.; Serry, A.-J.; Ducrot, P. (2020). Appropriation of the Front-of-Pack Nutrition Label Nutri-Score across the French Population: Evolution of Awareness, Support, and Purchasing Behaviors between 2018 and 2019. *Nutrients* 2020, 12, 2887. https://doi.org/10.3390/nu12092887.

Signal, L.; Lanumata, T.; Mhurchu, C.N.; Gorton, D. (2012). Front-of-pack nutrition labelling in New Zealand: An exploration of stakeholder views about research and implementation. *Health Promot. J.* Aust.2012, 23, 48–51.

Small, H. (1973). Co-citation in the scientific literature: A new measure of the relationship between two documents. *J. Am. Soc. Inf. Sci.* 1973, 24, 265–269. https://doi.org/10.1002/asi.4630240406.

Srour, B.; Fezeu, L.K.; Kesse-Guyot, E.; Allès, B.; Méjean, C.; Andrianasolo, R.M.; Chazelas, E.; Deschasaux, M.; Hercberg, S.; Galan, P. (2019). Ultra-processed food intake and risk of cardiovascular disease: Prospective cohort study (NutriNet-Santé). *BMJ* 2019, 365, 11451.

Storcksdieck Genannt Bonsmann, S.; Marandola, G.; Ciriolo, E.; van Bavel, R.; Wollgast, J. F(2020). Front-of-Pack Nutrition Labelling Schemes: A Comprehensive Review; *Joint Research Centre* (European Commission): Brussels, Belgium, 2020.

Ström, E.; Söderhäll, S. (2002). Beneficial effect of long term intravenous bisphosphonate treatment of osteogenesis imperfecta. *Arch. Dis. Child.* 2002, 86, 356–364.

Talati, Z.; Pettigrew, S.; Hughes, C.; Dixon, H.; Kelly, B.; Ball, K.; Miller, C. (2016a). The combined effect of front-of-pack nutrition labels and health claims on consumers' evaluation of food products. *Food Qual. Prefer.* 2016, 53, 57–65. https://doi.org/10.1016/j.foodqual.2016.05.016.

Talati, Z.; Pettigrew, S.; Kelly, B.; Ball, K.; Dixon, H.; Shilton, T. (2016b). Consumers' responses to front-of-pack labels that vary by interpretive content. *Appetite* 2016, 101, 205–213. https://doi.org/10.1016/j.appet.2016.03.009.

Talati, Z.; Pettigrew, S.; Neal, B.; Dixon, H.; Hughes, C.; Kelly, B.; Miller, C. (2017). Consumers' responses to health claims in the context of other on-pack nutrition information: A systematic review. *Nutr. Rev.* 2017, 75, 260–273. https://doi.org/10.1093/nutrit/nuw070.

Talati, Z.; Norman, R.; Kelly, B.; Dixon, H.; Neal, B.; Miller, C.; Pettigrew, S. (2018a). A randomized trial assessing the effects of health claims on choice of foods in the presence of

front-of-pack labels. *Am. J. Clin. Nutr.* 2018, 108, 1275–1282. https://doi.org/10.1093/ajcn/nqy248.

Talati, Z.; Pettigrew, S.; Kelly, B.; Ball, K.; Neal, B.; Dixon, H.; Shilton, T.; Miller, C. (2018b). Can front-of-pack labels influence portion size judgements for unhealthy foods? *Public Health Nutr.* 2018, 21, 2776–2781. https://doi.org/10.1017/s1368980018001702.

Talati, Z.; Egnell, M.; Hercberg, S.; Julia, C.; Pettigrew, S. (2019a). Consumers' Perceptions of Five Front-of-Package Nutrition Labels: An Experimental Study Across 12 Countries. *Nutrients* 2019, 11, 1934. https://doi.org/10.3390/nu11081934.

Talati, Z.; Egnell, M.; Hercberg, S.; Julia, C.; Pettigrew, S. (2019b). Food Choice Under Five Front-of-Package Nutrition Label Conditions: An Experimental Study Across 12 Countries. *Am. J. Public Health* 2019, 109, 1770–1775. https://doi.org/10.2105/ajph.2019.305319.

Tangari, A.H.; Burton, S.; Davis, C. (2014). Do They Have Your Number? Understanding the Moderating Role of Format Effects and Consumer Numeracy for Quantitative Front-of-Package Nutrition Claims. *J. Consum. Aff.* 2014, 48, 620–633. https://doi.org/10.1111/joca.12041.

Teisl, M.F.; Levy, A.S.; Derby, B.M. (1999). The Effects of Education and Information Source on Consumer Awareness of Diet–Disease Relationships. *J. Public Policy Mark.* 1999, 18, 197–207. https://doi.org/10.1177/074391569901800206.

Teisl, M.F.; Bockstael, N.E.; Levy, A. (2001). Measuring the Welfare Effects of Nutrition Information. Am. *J. Agric. Econ.* 2001, 83, 133–149. https://doi.org/10.1111/0002-9092.00142.

van der Bend, D.L.; Lissner, L. (2019). Differences and similarities between front-of-pack nutrition labels in Europe: A comparison of functional and visual aspects. *Nutrients* 2019, 11, 626.

Vanepps, E.M.; Roberto, C.A.; Park, S. (2016). Economos, C.D.; Bleich, S.N. Restaurant Menu Labeling Policy: Review of Evidence and Controversies. *Curr. Obes. Rep.* 2016, 5, 72–80. https://doi.org/10.1007/s13679-016-0193-z.

van Herpen, E.; Seiss, E.; van Trijp, H.C. (2012). The role of familiarity in front-of-pack label evaluation and use: A comparison between the United Kingdom and The Netherlands. *Food Qual. Prefer*. 2012, 26, 22–34.

van Herpen, E.; Hieke, S.; van Trijp, H.C. (2014). Inferring product healthfulness from nutrition labelling. The influence of reference points. *Appetite* 2014, 72, 138–149. https://doi.org/10.1016/j.appet.2013.10.012.

Vaqué, L. G. (2016). EU Regulation of Nutrition Labelling: An Irreversible Factor in the Deterioration of the Single Food Market. Eur. *Food Feed Law Rev.* 2016, 11, 9.

Vogel, R.; Güttel, W.H. (2013). The Dynamic Capability View in Strategic Management: A Bibliometric Review. *Int. J. Manag. Rev.* 2013, 15, 426–446. https://doi.org/10.1111/ijmr.12000.

Wang, G.; Fletcher, S.M.; Carley, D.H. (1995). Consumer Utilization of Food Labeling as a Source of Nutrition Information. *J. Consum. Aff.* 1995, 29, 368–380. https://doi.org/10.1111/j.1745-6606.1995.tb00052.x.

Wansink, B.; Sonka, S.T.; Hasler, C.M. (2004). Front-label health claims: When less is more. *Food Policy* 2004, 29, 659–667. https://doi.org/10.1016/j.foodpol.2004.10.004.

Wąsowicz, G.; Styśko-Kunkowska, M.; Grunert, K.G. (2015). The meaning of colours in nutrition labelling in the context of expert and consumer criteria of evaluating food product healthfulness. *J. Health Psychol.* 2015, 20, 907–920. https://doi.org/10.1177/1359105315580251.

Werth, P.M.; Musicus, A.A.; Bragg, M.; Graham, D.J.; Elbel, B.; Roberto, C.A. (2018) Comparing five front-of-pack nutrition labels' influence on consumers' perceptions and purchase intentions. *Prev. Med.* 2018, 106, 114–121. https://doi.org/10.1016/j.ypmed.2017.10.022.

World Health Organization (2019). Guiding Principles and Framework Manual for Front-of-Pack Labelling for Promoting Healthy Diet; World Health Organization: Geneva, Switzerland, 2019.

World Health Organization (2020). Obesity and Overweight; World Health Organization: Geneva, Switzerland, 2020.

Zhang, Y.; Chen, J.T.; Wang, S.; Andrews, J.C.; Levy, A. (2017). How Do Consumers Use Nutrition Labels on Food Products in the United States? *Top. Clin. Nutr.* 2017, 32, 161–171. https://doi.org/10.1097/tin.0000000000000101.

2. Chapter 2 - Effects on consumers' subjective understanding of a new front-of-pack nutritional label: a study on Italian consumers

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Abstract

Front-of-pack nutritional label (FOPL) systems have been developed worldwide to amplify and simplify nutritional information and induce healthier choices. This study explores consumers' internal reactions – in terms of subjective understanding and liking – to a new FOPL: the NutrInform Battery. The investigation aims to assess the clear comprehension by consumers of the information provided by the NutrInform Battery FOPL scheme, based on a sample of 200 Italian respondents, in a real-life setting, with products representative of the most widely consumed food categories, using a between-subject design. Participants were randomly assigned to one of the two conditions: products marked with NutrInform Battery or Nutri-Score labels. The results provided evidence of the effectiveness of NutrInform Battery in being perceived by consumers as an informative FOPL scheme. Specifically, consumers found NutrInform Battery more informative and helpful than Nutri-Score in terms of their understanding of the product composition.

Keywords: Front-of-pack nutritional label; Nutri-Score; NutrInform Battery; subjective understanding; liking; Italy

2.1. Introduction

Many different front-of-pack nutritional labels (FOPLs) have been introduced worldwide to amplify and simplify the nutritional information presented on food packages, and thus help average consumers make healthier choices. On the other hand, such systems are also useful in stimulating manufacturers towards the reformulation of certain products (Kanter *et al.* 2018; Van der Bend and Lissner 2019). Several countries have implemented different FOPL systems

[10] The study was developed by MFM, SR, AG also following a scientific protocol approved by the Italian Authorities; data were analyzed by MFM, SR, AG; data interpretation was undertaken by MFM, SR, AG; writing - original draft preparation was carried out by MFM, SR, AG. All authors have read and agreed to the published version of the manuscript.

with the purpose of supporting their health policies, aimed at reducing the consumption of products that contain high amounts of sugar, sodium or saturated fat. For this reason, the World Health Organization (WHO) advocates FOPL as a policy tool for tackling the progressive global diffusion of obesity and diet-related non-communicable diseases (WHO 2019).

In Europe, the debate on the most effective FOPL to improve consumer health is ongoing and there is no consensus or harmonised norm regarding how a FOPL should be designed. Several labelling systems have been introduced in the past in different areas worldwide, or are currently under experimental use, ranging from those with specific and detailed nutrients to simple and visual "*health logos*", with an intermediate role played by summary indicators. Examples of "*nutrient-based systems*" are FOPL that only present factual nutritional information, such as Reference Intake (RI) (Boztug *et al.* 2015; Hodgkins *et al.* 2015; Arrúa *et al.* 2017), known also as Guideline Daily Amount (GDA), FOPL that combines factual information with easy-to-interpret visuals, such as the Multiple Traffic Light (Emrich *et al.* 2017; Machín *et al.* 2018a, 2018b), and those that integrate factual information with negative health messages, such as Warning Labels (Cabrera *et al.* 2017; Khandpur *et al.* 2018; Reyes *et al.* 2019). Examples of "*summary indicators*" are the Health Star Rating (Hamlin and McNeill 2016; Mhurchu *et al.* 2017; Lundeberg *et al.* 2018) and the Nutri-Score (Ducrot *et al.* 2015a, 2015b; Julia and Hercberg 2017a, 2017b), while examples of simple and visual "health logos" are the Keyhole (Wang *et al.* 2016; Van der Bend and Lissner 2019) and the Choices Programme (Vyth *et al.* 2012; Jansen and Roodenburg 2016; Roodenburg 2017).

This study explores consumers' internal reactions – in terms of subjective understanding and liking – to a new enriched informative FOPL: the NutrInform Battery. A study conducted on Italian families investigates the perception that consumers have about this new FOPL. The study provides evidence for the effectiveness of NutrInform Battery considering its informative aims and distinguishes it from Nutri-Score, a summary FOPL with the different purpose of helping consumers make healthier choices.

The rest of the paper is organised as follows. First, we present the NutrInform Battery and we review prior research on consumers' reactions to FOPL. We then present the results of the study. Finally, we discuss the main implications, pointing out the limitations of our work and paving the way for future research.

A new FOPL: the NutrInform Battery

The NutrInform Battery was elaborated in 2018–2019 in Italy with the involvement of four ministries (Economic Development, Agriculture, Health and Foreign Affairs) and the technical and scientific assistance of two governmental Research Institutes (ISS National Institute of Public Health and CREA Food and Nutrition Research Centre).

The aim of NutrInform Battery is to help and empower consumers in making decisions regarding their daily food consumption in an informed way. These choices are made possible by presenting the content of the calories and key nutrients (salt, fat, saturated fats and sugar) in a portion and how much these nutrients contribute in percentage to the daily dietary intake of an average person. The NutrInform Battery informs consumers on the amount of calories, sugar, fats, saturates and salt per portion to comply with art. 35 of the Regulation (EU) No. 1169/2011. However, the scheme is flexible and it could also be used, if necessary, to inform consumers on the amount of other nutrients, for example those considered "positive" as fibres, pursuant to art. 30, paragraph 2, letter of Regulation (EU) No. 1169/2011. In addition, the NutrInform Battery combines factual information on a portion with an easy-to-interpret visual, the battery symbol, which is able to help consumers in understanding nutritional information. For reference, the portion was selected as recommended by the official Italian dietary guidelines ("Reference Assumption Levels of Nutrients and Energy for the Italian population" – LARN). Therefore, it is possible to categorise the NutrInform Battery as an enriched informative FOPL.

The battery icon is an internationally recognized symbol used in the case of NutrInform Battery FOPL to show at a glance the level of energy and main nutrients contained in a portion of product versus the daily RIs. This graphic representation allows consumers to understand immediately how much that amount of food contributes to the RI of energy and nutrients that have a significant impact on health. The level of replenishment corresponds to the percentage of dietary reference assumption, based on the European Reference Intakes (EFSA), as indicated also in Annex XIII of the Regulation (EU) No. 1169/2011. The signal is given by the sense of "full" versus "empty" and, in association with the concept of volume, it allows the message to be transmitted not only at the time of purchase, but also when the food is displayed in the pantry or consumed at home to allow consumers to follow a balanced, varied and healthy daily diet. The concept of replenishment versus emptiness still available for other foods, empowers consumers to choose and eat foods taking into account the overall diet. Consumers can easily

develop their daily diet balancing the food products they choose, provided that they do not exceed the replenishment of the battery for each nutrient.

Consumers' understanding and elaboration of FOPL

Given the aims and purposes of this enriched informative FOPL, it is fundamental to test the NutrInform Battery to assess its ability to inform consumers on the nutritional values of foods. In order to address it, the framework developed by Grunert and Wills (2007) has been used. It takes inspiration from two relevant streams of research about the effects of nutrition information on consumers: consumer decision-making and attitude formation and change. This framework is also the most popular in the studies examining how FOPLs influence consumers' understanding of nutrition information and affect their food choices (Chauliac and Hercberg 2012; Méjean *et al.* 2013, 2014; Ducrot *et al.* 2015a, 2015b; Julia *et al.* 2015a, 2015b, 2017; Egnell *et al.* 2018a, 2018b, 2019; Khandpur *et al.* 2018; Talati *et al.* 2019).

Research focussed on consumer decision-making (Bettman 1979; Bettman *et al.* 1998; Peter *et al.* 1999; Solomon *et al.* 2006) addresses the process behind people's product choices when there are multiple viable options, analysing how these choices are influenced by the available information. Meanwhile, the stream of research regarding attitude information and change (Petty and Cacioppo 1981; McGuire 1985; Eagly and Chaiken 1993) deals with how consumers manage and synthesise the available information to determine its relevance, which is generally a precondition for having one's behaviour impacted by such information.

The model derived from these two streams features the following phases: exposure, perception, understanding and liking, and finally use. In order for nutritional labels to have an effect, consumers must be exposed to them and be aware of them. Then, consumer perception and subsequent understanding and liking will follow and will impact consumer knowledge and consumer evaluation and choices. In this study, we consider specifically consumer understanding and liking as internal individual responses to FOPL exposure.

The understanding can be of two types: subjective and objective. We focussed on the subjective one: the meanings that consumers derive from the perceived label information and the extent to which consumers believe they have understood the communication in a relevant way. By contrast, the objective understanding is whether the meaning the consumer has attached to the FOPL is compatible with the meaning that the sender of the FOPL intended to

communicate, that is not in our interest since NutrInform Battery is based on factual nutrient information that has not been re-elaborated by the sender.

The other response considered is liking. Consumers may like a label because of the colours and symbols used, or because they think it is easy to understand or useful. Liking is an important aspect for acceptability and elaboration (Ducrot *et al.* 2015a). Understanding and liking do not need to be linked together, but they can jointly contribute to consumers' response to the label itself and to the memorisation of the information presented for the generation and the development of nutrition knowledge.

This study involves the new enriched informative FOPL NutrInform Battery and the most widely used and tested summary Nutri-Score label, a colour and alphabetic coded label without any factual information, whose aim is to help consumers make healthier choices and to stimulate product reformulation towards healthier product composition. Specifically, given their different purposes, we expect NutrInform Battery to perform better than Nutri-Score, in terms of its perceived ability to inform consumers. In other words, we expect that consumers will find NutrInform Battery more informative and helpful in terms of their understanding of the product composition. This study should therefore provide evidence of the effectiveness of NutrInform Battery considering its aims.

Our theoretical approach, complementary to studies that measure objective understanding (Ducrot *et al.* 2015b; Egnell *et al.* 2018a, 2018b, 2019) and the use of FOPL in purchasing situations, constituted a first attempt to simultaneously assess several different aspects of the overall subjective understanding of FOPL.

2.2. Methods and materials

Stimuli

NutrInform Battery and Nutri-Score are used as stimuli materials in the present study. With regards to NutrInform Battery, as consumers usually see the battery symbol on technological products, we have recognized the utility to test the correct understanding of this symbol in the specific context of food products. To do that, a pilot qualitative study has been conducted. In order to solicit positive or negative narrative accounts of thoughts and emotions felt in front of different stimuli, a Web-based survey system was used. Respondents were randomly assigned to one of the four following conditions: mobile-phone battery 15% charged, mobile phone

battery 75% charged, NutrInform Battery (sugars information) at 15% level, NutrInform Battery (sugars information) at 75% level[11]. Concerning food, the nutrient showed is sugar, as it is the nutrient that consumers rely on the most to consider the healthiness of the food. The instructions were: "Observe the image in front of you carefully and write your thoughts in brief" and then "Observe the image in front of you carefully and write your emotions in brief". Following the selections, respondents had to provide a rich description of the situation, expressing details regarding what they saw in front of them and what feelings were related. Three hundred and sixty-seven Italian individuals, subscribed to "Prolific" research platform, participated in the study (44.9% female and 55.1% male).

Results showed that the reported narratives strictly depended on the graphic conditions respondents saw, as the interpretation of the stimulus was closely related to the context in which the stimulus was presented. The considerations made on the battery symbol in the case of electronic devices were not transferred by analogy (Gregan-Paxton and John 1997; Gregan-Paxton and Page 2003) on the interpretation of nutritional information, but feelings and thoughts were exactly the opposite in the two contexts.

The Chi-square analysis highlighted a significant (p=.000) dependence of the valence levels on the context in which the battery was provided.

Indeed, in the case of mobile-phone battery 15% charged, respondents reported mainly negative thoughts and feelings associated with anxiety and preoccupation derived by the urgency to recharge the battery of the device. By contrast, respondents who saw the food battery at 15% level, reported neutral or positive thoughts and emotions, that were principally related to the utility of the information provided. Respondents appreciated the fact to be informed in a clear and useful way, that allowed them to pay attention with respect to their overall daily diet. These results have been completely reversed in the 75% battery condition. Indeed, respondents highlighted positive thoughts and feelings in front of the mobile-phone picture, which transmitted a sense of happiness, calm and security derived by a level of charge which was considered as satisfying by all the participants. Instead, the same level of charge in the case of the food battery provoked negative thoughts and negative feelings among respondents, derived principally by an excessive amount of sugars contained in the portion, which caused a sense of

[11] Stimuli available in Appendix 1

preoccupation and guilt among participants. Therefore, these results confirmed that respondents accurately understand the different meanings that the battery symbol has in relationship with the specific context in which it is introduced.

Design and study population

A between-subject design was used for this study. Two different conditions were created: condition 1 with NutrInform Battery FOPL and condition 2 with Nutri-Score FOPL. Each condition has the same product categories: sauces, yogurt, biscuits, crackers and processed meat[12]. Moreover, each category was composed of a conventional product (the first one mentioned in the following list) and a "light" version (the second one mentioned) of the same product, for a total of 10 food products: sauces (tomato and ricotta and tomato and basil), yogurt (fruit yogurt and zero fat fruit yogurt), crackers (classic and corn), biscuits (classic and without sugar) and processed meat (salami and cooked ham). The rationale for the inclusion of two different alternatives in each product category was related to the difference in product composition and consequently in its representation in terms of FOPLs. These two different representations allow consumers to better understand how each type of FOPL work. The food products, with their correspondent labels, were delivered by the interviewers through a home visit in two time points: at the start of the trial and then approximately 15 days later (in the middle of the test period) in sufficient quantity and adequate duration/expiry date (specifically, for fresh products with an expiry date of not less than 4–5 weeks). The total study length was 4 weeks. Two homogenous groups of Italian families, representative of the Italian population, were randomly assigned to the two conditions. Therefore, each responsible for food purchases, representative of each family, had to rate understanding and liking of the FOPL he/she saw (NutrInform Battery or Nutri-Score) associated to each of the 10 products presented above. Group creation took into account geographical area[13] number of people in the family, and age and gender of the family member responsible for food purchases (Table 1). Exclusion criteria regarded families including people that work as journalists or communication agency workers for the media, for research institutions, food producers and food distributors. Families were assigned to the two groups in a random way.

Table 1. General characteristics of each group (n=100 adults) in terms of respondents (responsible for food purchases)

[12] Example of stimuli in Appendix 1

[13] The four geographical areas are: Area 1 North West (Piedmont – Valle d'Aosta – Liguria – Lombardy), Area 2 North East (Veneto – Friuli V. Giulia – Trentino A.A. – Emilia R.), Area 3 Center (Tuscany – Lazio – Marche – Abruzzo – Molise – Sardinia) and Area 4 South and Sicily (Campania – Calabria – Basilicata – Apulia – Sicily).

Variables	Group 1 (NutrInform Battery) (n=100)	Group 2 (Nutri-Score) (n=100)
Age (years)		
≤ 34	15%	15%
35-44	20%	20%
45-54	20%	20%
55-64	17%	17%
65+	28%	28%
Gender		
Men	32%	32%
Women	68%	68%
Geographical area		
Area 1	28%	28%
Area 2	20%	20%
Area 3	23%	23%
Area 4	29%	29%
Family components		
1	29%	29%
2	28%	28%
3	20%	20%
4	17%	17%
5	6%	6%

The two groups present comparable socio-demo characteristics

Data collection

A questionnaire was administered for the present study. At the beginning, all the respondents (responsible for purchases in the family) answered questions related to education, occupation and perceived socioeconomic conditions. The information is provided in Table 2.

Table 2. Education, occupation and perceived socio-economic conditions of respondents (responsible for food purchases)

Variables	Group 1 (NutrInform Battery) (n=100)	Group 2 (Nutri-Score) (n=100)
Education		
Middle school or lower	20%	26%
High school diploma	54%	46%
Bachelor or higher	26%	28%
Occupation		
Self-employer, independent worker	12%	10%
Managerial staff	5%	7%
Intermediate profession/office staff	25%	25%
Professor	2%	6%
Student	0%	1%
Blue collar/manual worker	12%	8%
Houseworker	10%	19%
Retired	23%	12%
Trader, farmer, craftsman, other specifie	9%	7%
Withour professional activity	2%	5%
Socio-economic conditions		
Low	20%	20%
Medium-Low	30%	30%
Medium-high	30%	30%
High	20%	20%

The focus of the questionnaire was to evaluate the subjective understanding and liking of a FOPL. Subjective understanding was based on several subdimensions: comprehensibility

design, help-to-shop and complexity. These sub-dimensions were inspired by previous research (Möser *et al.* 2010; Smith Edge *et al.* 2014). Given the between-subject design, all questions were answered only for the assigned FOPL by the respondents. The respondents' subjective understanding and liking of the different labels were assessed in two periods: at the beginning of the test, right after the product delivery, and at the end of the test-period.

The study collected the following measures:

1. *Subjective understanding*: using a seven-point Likert scale, participants expressed their perception and comprehension of the label they saw. Their subjective understanding was evaluated through several indicators:

a. *Comprehensibility/design*. Measured through the following items (Möser *et al.* 2010): "I feel well informed by the food label", "This label is believable and trustworthy" and "This label is easy to interpret" (α=.92);

b. *Help to shop*. Measured through the following items (Möser *et al.* 2010): "This label helps me to understand the product composition", "This label helps me to understand different nutritional values" and "This label makes it easier to choose food" (α=.93);

c. *Complexity (reduction)*. Measured through the following items (Moser *et al.* 2010): "The food label is rather extensive", "Using this food label to choose foods is better than just relying on my own knowledge about what is in them" (α=.85).

2. *Liking*: using a seven-point Likert scale, participants evaluated their level of liking towards the FOPL. They were asked: "How do you evaluate the label?" based on the following scales: "bad/ good", "unfavorable/favorable" and "negative/positive" (Allen and Janiszewski 1989) (α=.96).

Pre-tests were conducted on several product classes during September–October 2019 in order to select relevant items for the main study. Pre-tests were conducted on the Prolific Academic platform using Italian food products of five different food categories: sauces, biscuits, crackers, yogurt and ready-sliced meat. No categories effect was identified on the relevant items.

Statistical analysis

We performed analyses on data from participants who had completed the questionnaire, using IBM SPSS Statistics 25 (Armonk, NY). We compared participants' evaluations using Students' t-tests. After evaluating the reliability, we calculated the means for the three variables: comprehensibility/design, help-to-shop and complexity. We made a similar calculation to assess liking. Finally, we compared both single items and scale means between the two FOPL. These analyses were developed for the two periods taken into consideration (immediately after the product delivery and at the end of the test-period).

2.3. Results

Subjective understanding and liking at the beginning of the test, after the product delivery

Overall, respondents expressed a general positive evaluation of the two FOPL. This result suggests that participants generally appreciate the presence of FOPL on food packages (Table 3)[14]. However, the data showed a clear informative meaning associated to NutrInform Battery.

Table 3. Subjective understanding and liking immediately after the delivery of the products: means and standard deviations

Variables	Item	FOPL NutrInform Battery condition (n=100)	FOPL Nutri-Score condition (n=100)	t-Test statistics	p value
Subjective Understanding					
Comprehensibility/ design:	I feel well informed by the food label	5.3 (1.5)	4.3 (2.0)	t(198)=4.04	p<.01
specific items	This label is beliavable and trustworthy	5.5 (1.2)	4.8 (1.7)	t(198)=3.59	p<.01
	This lavel is easy to interpet	5.3 (1.6)	4.5 (2.1)	t(198)=3.29	p<.01
Comprehensibility/ design: means		5.4 (1.3)	4.5 (1.8)		
Help-to-shop: specific items				t(198)=3.91	p<.01
	This label helps me to understand the product composition	5.2 (1.7)	4.0 (2.0)	t(198)=4.67	p<.01
	This label helps me to understand different nutritional values	5.5 (1.5)	4.5 (1.9)	t(198)=4.13	p<.01
	This label makes it easier to choose food	5.2 (1.5)	4.3 (1.9)	t(198)=3.87	p<.01
Help-to-shop: means		5.3 (1.5)	4.2 (1.8)	t(198)=4.55	p<.01
Complexity (reduction): specific items	This label is rather extensive	4.7 (1.7)	3.6 (2.0)	t(198)=4.46	p<.01
	Using this food label to choose foods is better than just relying on my own knowlegde aboaut what is in them	4.7 (1.7)	3.8 (1.8)	t(198)=3.62	p<.01
Complexity (reduction): means		4.7 (1.5)	3.7 (1.8)	t(198)=4.36	p<.01
Liking					
Liking: specific items	Bad/good	5.3 (1.5)	4.6 (1.6)	t(198)=3.16	p<.01
	Unfavorable/favorable	5.3 (1.5)	4.8 (1.6)	t(198)=2.45	p=.02
	Negative/positive	5.3 (1.5)	4.7 (1.6)	t(198)=2.96	p<.01
Liking: means		5.3 (1.4)	4.7 (1.6)	t(198)=2.97	p<.01

In detail, regarding comprehensibility/design, which measures how much respondents consider the label to be able to inform, to be believable and easy to understand, NutrInform Battery outperformed Nutri-Score with a mean of 5.4 vs. 4.5 (t(198)=3.91; p<.01).

[14] Regarding subjective understanding and liking, no differences were found for NutrInform Battery depending on the educational level. By contrast, some significant effects were found for Nutri-Score in the first test period. Further research should better explore these effects

This same trend occurred for help-to-shop, which reflects the label's ability to help customers understand product composition and make related decisions ($M_{NutrInform\ Battery}$=5.3 vs. $M_{Nutri\text{-}Score}$=4.2, t(198)=4.55, p<.01) and for complexity, which reflects the extent of the label's information ($M_{NutrInform\ Battery}$ 4.7 vs. $M_{Nutri\text{-}Score}$ 3.7 t(198)=4.36, p<.01). In all the measured scales, related to informative aspects, NutrInform Battery was considered very positively. Regarding liking, NutrInform Battery (5.3) received higher scores than Nutri-Score (4.7) (t(198)=2.97, p<.01). In conclusion, these results showed that NutrInform Battery consistently performed better than Nutri-Score in terms of subjective understanding and liking for all categories.

Subjective understanding and liking at the end of the test period

The results referring to the period immediately after product delivery were confirmed at the end of the test period, after 4 weeks of label utilisation (Table 4)[15].

Table 4. Subjective understanding and liking immediately after the end of the test period: means and standard deviations

Variables	Item	FOPL NutrInform Battery condition (n=100)	FOPL Nutri-Score condition (n=100)	t-Test statistics	p value
Subjective Understanding					
Comprehensibility/ design:	I feel well informed by the food label	5.5 (1.3)	4.9 (1.6)	t(198)=2.85	p<.01
specific items	This label is beliavable and trustworthy	5.7 (1.3)	5.2 (1.6)	t(198)=2.46	p<.05
	This lavel is easy to interpet	5.6 (1.3)	5.1 (1.6)	t(198)=2.36	p<.05
Comprehensibility/ design: means		5.6 (1.2)	5.1 (1.5)		
Help-to-shop: specific items				t(198)=2.74	p<.01
	This label helps me to understand the product composition	5.6 (1.4)	4.8 (1.8)	t(198)=3.51	p<.01
	This label helps me to understand different nutritional values	5.6 (1.3)	4.9 (1.7)	t(198)=3.21	p<.01
	This label makes it easier to choose food	5.4 (1.4)	4.9 (1.6)	t(198)=2.42	p<.05
Help-to-shop: means		5.5 (1.3)	4.9 (1.6)	t(198)=3.22	p<.01
Complexity (reduction): specific items	This label is rather extensive	5.4 (1.4)	4.5 (1.7)	t(198)=4.22	p<.01
	Using this food label to choose foods is better than just relying on my own knowlegde aboaut what is in them	5.1 (1.6)	4.4 (1.9)	t(198)=2.62	p<.05
Complexity (reduction): means		5.2 (1.4)	4.5 (1.7)	t(198)=3.53	p<.01
Liking					
Liking: specific items	Bad/good	5.5 (1.3)	5.0 (1.5)	t(198)=2.41	p<.05
	Unfavorable/favorable	5.6 (1.3)	5.0 (1.5)	t(198)=2.97	p<.01
	Negative/positive	5.6 (1.3)	5.1 (1.5)	t(198)=2.90	p<.01
Liking: means		5.6 (1.2)	5.1 (1.5)	t(198)=2.85	p<.01

Regarding comprehensibility/design, NutrInform Battery has a higher score than Nutri-Score with a mean of 5.6 vs. 5.1 (t(198)=2.74; p<.01). The same trend occurred for help-to-shop ($M_{NutrInform\ Battery}$=5.5 vs. $M_{Nutri\text{-}Score}$=4.9, t(198)=3.22, p<.01), for complexity ($M_{NutrInform\ Battery}$=5.2 vs. $M_{Nutri\text{-}Score}$=4.5, t(198)=3.53, p<.01) and for liking ($M_{NutrInform\ Battery}$=5.6 vs. $M_{Nutri\text{-}Score}$=5.1, t(198)=2.85, p<.01). In both periods, therefore, consumers found NutrInform Battery

[15] Regarding subjective understanding and liking, no differences were found for both NutrInform Battery and Nutri-Score depending on the educational level

(compared to Nutri-Score) more informative and helpful in terms of understanding of the product composition, in alignment with the purpose of the enriched informative FOPL.

2.4. Discussion

The study presented the NutrInform Battery, a new enriched informative FOPL, whose aim is to help and empower consumers in making a decision regarding their daily food consumption in an informed way. After having detailed the NutrInform Battery purpose and its main characteristics in terms of graphics and type of information provided, we described the framework used in this study to test consumers' subjective understanding of the information contained in the FOPL. Using this framework, the study compared the NutrInform Battery with the Nutri-Score, as the mostly widely used and tested summary label, whose aim is more focussed on promoting healthier food choices and product reformulation. The test conducted on Italian families provided evidence on the positive performance of NutrInform regarding subjective comprehension, highlighting the effectiveness of this label in being perceived by consumers as an informative FOPL in terms of understanding of the product composition.

This study, therefore, extends the existing research regarding informative FOPL and its ability to inform and empower consumers (De la Cruz-Gongora *et al.* 2017; Vargas-Meza *et al.* 2019a, 2019b), analysing two labels that, to our knowledge, have not been fully tested yet with regards to subjective understanding. Indeed, the study of De la Cruz-Gongora *et al.* (2017) explored the subjective understanding related to the Health Logos, Health Star Rating, GDA's and Multiple Traffic Light labels, while the ones of Vargas-Meza *et al.* (2019a, 2019b) focussed on Warning labels, Health Star Rating, Multiple Traffic Light and GDA's implemented in Mexico. Our results, therefore, complemented the previous research including a comparison between the two FOPL NutrInform Battery and Nutri-Score and extended the study from Latin America, where past studies had been conducted, to Italy, using a panel of Italian families.

Another interesting aspect of this study is the fact that the understanding related to the two FOPL has been explored in terms of subjective understanding, while past studies principally focus on the objective facet. Indeed, the understanding can be of two types: subjective and objective. Subjective understanding refers to the meanings that consumers derive from the perceived label information and the extent to which consumers believe they have understood the communication in a relevant way, while objective understanding is whether the meaning

the consumer has attached to the FOPL is compatible with the meaning that the sender of the FOPL intended to communicate. We decided to focus on subjective understanding because in the case of NutrInform Battery, objective understanding cannot be the primary focus since the message the sender intends to communicate is only based on factual-nutrient information and not on summary, re-elaborated information, reducing any risks of misunderstanding for consumers. Therefore, whereas objective understanding reflects whether consumers understand what the sender intends to communicate, subjective understanding reflects what consumers believe they have understood in terms of factual-nutrient information relevant for their nutritional knowledge. Thus, this facet of understanding is aligned with the aim of the NutrInform Battery and at the same time enriches the knowledge in terms of understanding Nutri-Score, that has been compared with other FOPL in various studies but focussing on the objective aspect. The studies of Egnell *et al.* (2018a, 2018b) compared the Nutri-Score with other summary labels: Health Star Rating, Multiple Traffic Light and Warning symbol and the informative/nutrient-specific label: RI. Results showed that summary FOPL was associated with the highest increase in objective understanding, and Nutri-Score was the one which performed better, followed by Multiple Traffic Light, as it significantly improved the ability of consumers to rank food healthiness. In this matter, the use of a colour-coded structure, instead of the monochrome one, and the presence of summary information appears to positively reduce the cognitive workload required for the ranking (Egnell *et al.* 2018a, 2018b). Future research should explore why there is a difference in Nutri-Score performance related to the two aspects of understanding. One reason, for example, that can positively act on objective understanding, which is generally studied through food products ranking in terms of healthiness, is the use of traffic light colours, as already highlighted in the studies of Egnell *et al.* (2018a, 2018b). Indeed, the presence of colour is recognized as a positive element to improve consumers' attention and understanding, and more specifically the different performances that colour-coded and monochromatic labels have in various studies. Several studies have highlighted the positive effect that colours have on FOPL salience, which can be then translated in an increase in attention and comprehension of the information provided (Hersey *et al.* 2013; Becker *et al.* 2015; Ducrot *et al.* 2015b). The colour-coded structure resulted as one of the key elements in helping consumers achieve better levels of objective comprehension, in the case of Egnell *et al.* studies explored above, and in the studies of Antúnez *et al.* (2015) and Bix *et al.* (2015), which demonstrated that response times are significantly higher for monochrome FOPL than colour coded labels. However, there are no unequivocal results which can assert that colour-coded

labels are better than monochromatic colour labels, in all situations. Indeed, the studies of Bialkova and Trijp (2010) and Bialkova *et al.* (2013) have shown that a monochromatic, rather than polychrome colouring, facilitates consumer attention and comprehension, supporting the results of our study where the monochrome NutrInform Battery label obtained better results than the colour-coded Nutri-Score. Future research could test if the presence of colour has the same relevance, for objective and subjective understanding, in helping consumers' comprehending the information.

This work has some limitations that suggest several potentially promising future research opportunities. First, as presented in the framework used, various phases characterise the consumer's decision-making process. In this study, we presented each of them, but we focussed only on subjective understanding and liking. However, further study could provide evidence regarding both the impact of nutrition knowledge on NutrInform Battery comprehension and the opposite, that is the impact of NutrInform Battery on nutrition knowledge, and on the evaluation, choices and consumption of food products so as to analyse its effects over the entire process. Future research could also compare the NutrInform Battery with other FOPL, to explore in more detail the different effects that can emerge in relation to the different scopes of FOPL. Additionally, future studies can be conducted across countries to see if cultural differences influence and modify results and to increase the size of the respondent sample. A final consideration is that all European FOPL schemes are currently applied on prepacked foods. However, the NutrInform Battery scheme could be applied in the future, also on unpacked foods. Moreover, to promote healthy and balanced diets among consumers, it would be important to have a mechanism that add up calories and nutrients intakes throughout the day, while having the possibility to track the energy and nutrients in foods compared with the daily recommended intakes. Further research could explore the understanding, acceptance and usability of supporting tools that, by combining information on prepacked and unpacked foods, could grant the maximum benefit in terms of information to consumers that are willing to balance their personal diet.

References

Allen CT, Janiszewski CA. (1989). Assessing the role of contingency awareness in attitudinal conditioning with implications for advertising research. *J Market Res.* 26(1): 30–43.

Antúnez L, Giménez A, Maiche A, Ares G. (2015). Influence of interpretation aids on attentional capture, visual processing, and understanding of front-of-package nutrition labels. *J Nutr Educ Behav.* 47(4):292–299.e1.

Arrúa A, Machín L, Curutchet MR, Martınez J, Antúnez L, Alcaire F, Giménez A, Ares G. (2017). Warnings as a directive front-of-pack nutrition labelling scheme: comparison with the Guideline Daily Amount and traffic-light systems. *Public Health Nutr.* 20(13):2308–2317.

Article 35 of Regulation (EU) No. 1169/2011 on the provision of food information to consumers. 2011. https://eurlex. europa.eu/legal-content/EN/ALL/?uri=CELEX%3A32011R1169.

Becker MW, Bello NM, Sundar RP, Peltier C, Bix L. (2015). Front of pack labels enhance attention to nutrition information in novel & commercial brands. *Food Policy.* 56: 76–86.

Bettman J. (1979). An information processing theory of consumer choice. Reading (MA): Addison-Wesley Pub. Co.; p. xiv, 402.

Bettman J, Luce M, Payne J. (1998). Constructive consumer choice processes. *J Consum Res.* 25(3):187–217.

Bix L, Sundar RP, Bello NM, Peltier C, Weatherspoon LJ, Becker MW. (2015). To see or not to see: do front of pack nutrition labels affect attention to overall nutrition information? *PLoS One*. 10(10):e0139732.

Bialkova S, Trijp H. (2010). What determines consumer attention to nutrition labels? *Food Qual Pref.* 21(8): 1042–1051.

Bialkova S, Grunert KG, Trijp H. (2013). Standing out in the crowd: the effect of information clutter on consumer attention for front-of-pack nutrition labels. *Food Policy*. 41:65–74.

Boztug Y, Juhl HJ, Elshiewy O, Jensen MB. (2015). Consumer response to monochrome Guideline Daily Amount nutrition labels. *Food Policy*. 53:1–8.

Cabrera M, Machín L, Arrúa A, Antúnez L, Curutchet MR, Giménez A, Ares G. (2017). Nutrition warnings as front-of-pack labels: influence of design features on healthfulness perception and attentional capture. *Public Health Nutr.* 20(18):3360–3371.

Chauliac M, Hercberg S. (2012). Changing the food environment: the French experience. Adv Nutr. 3(4):605S–610S.

De la Cruz-Gongora V, Torres P, Contreras-Manzano A, Jauregui de la Mota A, Mundo-Rosas V, Villalpando S, Rodrıguez-Oliveros G. (2017). Understanding and acceptability by Hispanic consumers of four front-of-pack food labels. *Int J Behav Nutr Phys Act.* 14(1):28.

Ducrot P, Méjean C, Chantal J, Kesse-Guyot E, Touvier M, Fezeu L, Hercberg S, Péneau S. (2015a). Effectiveness of front-of-pack nutrition labels in French adults: results from the NutriNet-Sante Cohort Study. *PLoS One*. 10(10):e0140898.

Ducrot P, Méjean C, Julia C, Kesse-Guyot E, Touvier M, Fezeu LK, Hercberg S, Péneau S. (2015b). Objective understanding of front-of-package nutrition labels among nutritionally at-risk individuals. *Nutrients*. 7(8): 7106–7125.

Eagly A, Chaiken S. (1993). The psychology of attitudes. Fort Worth (TX): Harcourt, Brace & Jovanovich; p. 794.

Egnell M, Ducrot P, Touvier M, Alles B, Hercberg S, Kesse- Guyot E, Chantal J. (2018a). Objective understanding of Nutri-Score Front-Of-Package nutrition label according to individual characteristics of subjects: comparisons with other format labels. *PLoS One*. 13(8):e0202095.

Egnell M, Talati Z, Gombaud M, Galan P, Hercberg S, Pettigrew S, Julia C. (2019). Consumers' responses to front-of-pack nutrition labelling: results from a sample from The Netherlands. *Nutrients*. 11:1817.

Egnell M, Talati Z, Hercberg S, Pettigrew S, Julia C. (2018b). Objective understanding of front-of-package nutrition labels: an international comparative experimental study across 12 countries. *Nutrients*. 10(10):1542.

Emrich TE, Qi Y, Lou WY, L'Abbe MR. (2017). Traffic-light labels could reduce population intakes of calories, total fat, saturated fat, and sodium. *PLoS One*. 12(2):e0171188.

Gregan-Paxton J, John D. (1997). Consumer learning by analogy: a model of internal knowledge transfer. *J Consum Res*. 24(3):266–284.

Gregan-Paxton J, Page M. (2003). How do consumers transfer existing knowledge? A comparison of analogy and categorization effects. *J Consum Psychol*. 13(4):422–430.

Grunert KG, Wills JM. (2007). A review of European research on consumer response to nutrition information on food labels. *J Public Health*. 15(5):385–399.

Hamlin R, McNeill L. (2016). Does the Australasian "Health Star Rating" front of pack nutritional label system work? *Nutrients*. 8(6):327.

Hersey JC, Wohlgenant KC, Arsenault JE, Kosa KM, Muth MK. (2013). Effects of front-of-package and shelf nutrition labeling systems on consumers. *Nutr Rev*. 71(1):1–14.

Hodgkins CE, Raats MM, Fife-Schaw C, Peacock M, Groppel-Klein A, Koenigstorfer J, Wasowicz G, Stysko-Kunkowska M, Gulcan M, Kustepeli Y. (2015). Guiding healthier food choice: systematic comparison of four front-of-pack labelling systems and their effect on judgements of product healthiness. *Br J Nutr*. 113(10): 1652–1663.

Jansen L, Roodenburg A. (2016). The use of food composition data in the Choices International Programme. *Food Chem.* 193:196–202.

Julia C, Ducrot P, Péneau S, Deschamps V, Méjean C, Fezeu L, Touvier M, Hercberg S, Kesse-Guyot E. (2015a). Discriminating nutritional quality of foods using the 5-color nutrition label in the French food market: consistency with nutritional recommendations. *Nutr J*. 14:100.

Julia C, Kesse-Guyot E, Ducrot P, Péneau S, Touvier M, Méjean C, Hercberg S. (2015b). Performance of a five category front-of-pack labelling system – the 5-colour nutrition label – to differentiate nutritional quality of breakfast cereals in France. *BMC Public Health*. 15:179.

Julia C, Péneau S, Buscail C, Gonzalez R, Touvier M, Hercberg S, Kesse-Guyot E. (2017). Perception of different formats of front-of-pack nutrition labels according to sociodemographic, lifestyle and dietary factors in a French population: cross-sectional study among the NutriNet-Sante cohort participants . *BMJ Open.* 7(6): e016108.

Julia C, Hercberg S. (2017a). Development of a new front-of-pack nutrition label in France: the five-colour Nutriscore. *Public Health Panorama*. 3(4):712–725.

Julia C, Hercberg S. (2017b). Nutri-Score: evidence of the effectiveness of the French front-of-pack nutrition label. *Ernaehrungs Umschau Int.* 64(12):181–187.

Kanter R, Vanderlee L, Vandevijvere S. (2018). Front-of-package nutrition labelling policy: global progress and future directions. *Public Health Nutr.* 21(8):1399–1408.

Khandpur N, Swinburn B, Monteiro CA. (2018). Nutrientbased warning labels may help in the pursuit of healthy diets. *Obesity* (Silver Spring). 26(11):1670–1671.

Lundeberg PJ, Graham DJ, Mohr GS. (2018). Comparison of two front-of-package nutrition labeling schemes, and their explanation, on consumers' perception of product healthfulness and food choice. *Appetite*. 125:548–556.

Machın L, Aschemann-Witzel J, Curutchet MR, Giménez A, Ares G. (2018a). Traffic light system can increase healthfulness perception: implications for policy making. *J Nutr Educ Behav*. 50(7):668–674.

Machín L, Aschemann-Witzel J, Curutchet MR, Giménez A, Ares G. (2018b). Does front-of-pack nutrition information improve consumer ability to make healthful choices? Performance of warnings and the traffic light system in a simulated shopping experiment. *Appetite*. 121:55–62.

McGuire WJ. (1985). Attitudes and attitude change. In: Lindzey G, Aronson E, editors. *Handbook of social psychology*. Vol. 2. 3rd ed. New York: Random House; p. 233–346.

Méjean C, Macouillard P, Péneau S, Hercberg S, Castetbon K. (2013). Consumer acceptability and understanding of front-of-pack nutrition labels. *J Hum Nutr Diet.* 26(5): 494–503.

Méjean C, Macouillard P, Péneau S, Lassale C, Hercberg S, Castetbon K. (2014). Association of perception of front-of-pack labels with dietary, lifestyle and health characteristics. *PLoS One.* 9(3):e90971.

Mhurchu CN, Eyles H, Choi YH. (2017). Effects of a voluntary front-of-pack nutrition labelling system on packaged food reformulation: the Health Star Rating System in New Zealand. *Nutrients*. 9(8):918.

Moser A, Hoefkens C, Van Camp J, Verbeke W. (2010). Simplified nutrient labelling: consumers' perceptions in Germany and Belgium. *J Verbr Lebensm*. 5(2):169–180.

Peter J, Olson J, Grunert K. (1999). Consumer behaviour and marketing strategy. London: McGraw-Hill.

Petty R, Cacioppo J. (1981). Attitudes and persuasion: classic and contemporary approaches. Dubuque (IA): W.C. Brown Co. Publishers.

Reyes M, Garmendia ML, Olivares S, Aqueveque C, Zacarıas I, Corvalan C. (2019). Development of the Chilean front-of package food warning label. *BMC Public Health*. 19(1):906.

Roodenburg A. (2017). Nutrient profiling for front of pack labelling: how to align logical consumer choice with improvement of products? *Proc Nutr Soc.* 76(3):247–254.

Smith Edge M, Toner C, Kapsak WR, Geiger CJ. (2014). The impact of variations in a fact-based front-of-package nutrition labeling system on consumer comprehension. *J Acad Nutr Diet.* 114(6):843–854.

Solomon M, Bamossy G, Askegaard S, Hogg M. (2006). Consumer behaviour, a European perspective. 3rd ed.Harlow (UK): Prentice Hall, Harlow.

Talati Z, Egnell M, Hercberg S, Julia C, Pettigrew S. (2019). Consumers' perceptions of five front-of-package nutrition labels: an experimental study across 12 countries. *Nutrients*. 11(8):1934.

Van der Bend DLM, Lissner L. (2019). Differences and similarities between front-of-pack nutrition labels in Europe: a comparison of functional and visual aspects. *Nutrients*. 11(3):626.

Vargas-Meza J, Jauregui A, Contreras-Manzano A, Nieto C, Barquera S. (2019a). Acceptability and understanding of front-of-pack nutritional labels: an experimental study in Mexican consumers. *BMC Public Health*. 19(1):1751.

Vargas-Meza J, Jauregui A, Pacheco-Miranda S, Contreras-Manzano A, Barquera S. (2019b). Front-of-pack nutritional labels: understanding by low- and middle-income Mexican consumers. *PLoS One*. 14(11):e0225268.

Vyth E, Steenhuis I, Brandt H, Roodenburg AJ, Brug J, Seidell JC. (2012). Methodological quality of front-of-pack labeling studies: a review plus identification of research challenges. *Nutr Rev*. 70(12):709–720.

Wang Q, Oostindjer M, Amdam GV, Egelandsdal B. (2016). Snacks with nutrition labels: tastiness perception, healthiness perception, and willingness to pay by Norwegian adolescents. *J Nutr Educ Behav*. (48)(2):104–111.

World Health Organization (WHO). 2019. Guiding principles and framework manual for front-of-pack labelling for promoting healthy diet. Geneva.

3. Chapter 3 - A cross-country experimental study on consumers' subjective understanding and liking on front-of-pack nutritional labels

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Abstract

Different Front-of-Pack (FOP) nutritional labels have been implemented in order to increase consumers' awareness of food nutritional quality and encourage healthier choices. However, few studies have analysed the effects of FOPLs on consumers' subjective understanding and liking across different socio-cultural contexts. This study tests the effect that the new enriched informative label NutrInform Battery and the summary label Nutri-Score have on subjective comprehension and liking across 2776 respondents of seven European countries (France, Germany, Greece, Italy, Portugal, Romania and Spain). Main effects regarding socio-demographic differences are also explored according to extant literature and highlighting significant effects of education and income. This study therefore extends the current research on subjective understanding and liking with a cross-country analysis. Findings suggest that NutrInform Battery can help consumers in understanding information in a relevant way, obtaining the highest performance across countries and showing limited impact of socio-cultural differences.

Keywords: Front-of-pack nutritional label; Nutri-Score; NutrInform Battery; subjective understanding; liking; cross-country

3.1. Introduction

In recent years, the increase in consumption of high- sugar, high-fat, high-salt and energy-dense food, combined with changes in lifestyle and a decreased physical activity, contributed to a sharp surge in the number of people affected by obesity (WHO 2020). According to some

[16] The study was developed by MFM, SR, AB, AG also following a scientific protocol approved by the Italian Authorities; data was analysed by MFM, SR, AB, AG; data interpretation was undertaken by MFM, SR, AB, AG; writing – original draft preparation was carried out by MFM, SR, AB, AG.

estimates, by 2025, obesity will increase in 44 countries and, as many as 33 of the 53 European states will be characterised by 1 in 5 people which will be over-weight (Pineda *et al.* 2018). Furthermore, the projections are not encouraging: some forecasts suggest that 51% of the world population will be obese by 2030 (Finkelstein *et al.* 2012). Given the magnitude of the problem, and without a clear intervention in order to revert the trends, serious negative consequences might affect part of the population, with subsequent risks on noncommunicable dis- eases (WHO 2020).

Therefore, also in light of the relationship between individuals' nutritional conditions and success in chronic disease prevention, helping consumers to make healthier food choices has become a priority for governments, authorities, socially responsible businesses and organisations, in their attempt to identify ways to control overweight and obesity.

The solution would require not only a potential change in formulation by producers of some specific pre-packaged products, but also, and more important, the development of a system that can help consumers taking food-eating decisions, eventually positively changing them, in an informed way. On their side, companies, institutions and society at large have increasingly committed to actions aimed at reformulating the nutritional information presented on food packages (van der Bend and Lissner 2019). While back-of-pack information already showed their effectiveness in generating healthier eating intentions on people who read those information (Barreiro-Hurle *et al.* 2010), a more "visible approach" would be required to widen the impact of labels. In particular, the introduction and diffusion in some countries of "Front-of-Pack Labels" (also, in the acronyms, "FOP labels" or "FOPLs"), i.e. labels that carry nutritional information on the front of the packaging of food products (van der Bend and Lissner 2019) that are not Nutrition Facts Panel (NFP), represents an important opportunity to increase consumer awareness, to link eating habits to the state of health, and to stimulate the reduction of the demand and consumption of products with high levels of sugars, sodium and saturated fats. FOPL in recent years have then become more and more part of the discussion among institutions, governments, firms and private citizens. The number of initiatives promoted by nutritionists, food scientists and the media has significantly increased. These initiatives all tend to create associations, direct and indirect, between the presence (or absence) of certain nutrients and health and well- being, with sometime the aim of "nudging", i.e. "gently" affecting consumer behaviours (Thaler and Sunstein 2008) towards a more balanced and healthier

personal diet, to which many improvements are connected for individual consumers and for the community. However, the absence of a unique worldwide regulation has generated, overtime, a great variety of FOP labels, often combined with equally heterogeneous regulatory policies, with a lack of unambiguous and incontrovertible evidences of an absolute superiority of a specific FOPL, affecting behaviours and the health of consumers. Scientific backing on previous cross-country studies, shows non- identical performances of different FOPL on variables along multiple steps of consumers' behaviour. The problem is then far from being solved, while the recent EU "Farm-to-Fork" Strategy highlights the need of harmonisation among FOPL within 2022 (European Commission 2020).

This paper aims at contributing to the current discussion by exploring subjective understanding and liking in seven European Countries, characterised by a different state of FOPLs' public debate and market penetration. Specifically, the study investigates the perception that consumers have on NutrInform Battery, a new Nutrient Specific enriched informative FOPL, and compare it with Nutri-Score, one of the most diffused Summary Label at EU level, designed to support consumers make healthier choices. The paper is organised in three sections. First, we briefly recap some FOPL alternatives present in the market, illustrate the selected FOPL classification utilised and its link with the main theoretical framework. We then show statistical analyses and the main results with specific attention to potential cross-interactions between FOPL and countries. Finally, we discuss the main implications, highlighting the limitations of our work and hypothesising new research avenues.

3.2. Conceptual framework and extant literature

In Europe, FOPLs were first introduced in the late 1980s in Sweden through the adoption of the Keyhole Logo (Kanter *et al.* 2018). In 2006, the European food and drink industry presented the Guideline Daily Amount (GDA), later known as Reference Intakes (RI). In 2011, the European Union introduced a Regulation (EU Regulation 1169/2011 2011) allowing Member States, together with Iceland, Norway, Liechtenstein and Switzerland, to develop, on a voluntary basis, FOPLs guidelines and stimulating a debate about the effectiveness of the different systems in use (van der Bend and Lissner 2019). In the absence of a FOP nutritional scheme that would be understandable and acceptable for all EU consumers, Member States and food business operators developed their own schemes, adapted to their consumers, and compliant with certain criteria. Examples are the Multiple Traffic Light (MTL) introduced in

the UK in 2013 by the Department of Health (European Parliaments and the Council 2020), the Nutri-Score (NS), adopted in France as of 2017, in Belgium as of 2019, in Germany as of 2020, and announced to be adopted in Luxembourg in 2021, and the NutrInform (NI) Battery System, a proposal from the Italian government in 2020. Outside Europe, other relevant systems are the Health Rating System (HSR), present on a voluntary basis in New Zealand as of 2014 (Hamlin and McNeill 2016) and the Warning Labels (WL) present in the Chilean market as of 2016 (Reyes *et al.* 2019). In 2018, at global level, a FOP scheme is present in more than 40 countries (Anvisa 2018).

Extant literature provided different definitions, taxonomies, and classifications of FOPLs (Kanter *et al.* 2018; van der Bend and Lissner 2019). In this paper, we adopt the current EU view on typologies and for- mats of FOPL, based on schemes implemented, or proposed, or announced at Member States and UK level (European Parliaments and the Council 2020). The approach distinguishes FOPL in two main categories: (1) "Nutrient Specific FOP" and (2) "Summary Labels". The first category is then clustered into two main sub-categories: (1a) "Numerical FOP", typically "non-directive", reductive/non-interpretative labels (Talati *et al.* 2017a; Newman *et al.* 2018; Ikonen *et al.* 2020) as the Reference Intake (RI), or the newly sub-mitted enriched informative NutrInform Battery (NI), and (1b) "Colour coded", as the semi-directive, evaluative/interpretative Multiple-Traffic Light (MTL). The second category, which includes directive and evaluative (interpretative) labels, is also clustered into the two main sub-categories of (2a) "Positive (endorsement) logos", as the Keyhole, the health logos and the Healthy Choices, and the (2b) "Graded indicators", as the Nutri-Score. The idea behind "summary labels" is to guide consumers towards the purchase of foods with a low content of specific ingredients (fats, sugar and sodium) and/or the presence of ingredients that are assumed to have a positive effect on health (e.g. vegetables, proteins, fibre, fruit), regardless of the frequency and dosage of the specific food intake and consumer's health status. In this perspective, evaluative/interpretative labels, such as Nutri-Score, tend to improve the amount of information provided by the Nutrition Fact Panel, making available a summary of the information shown by the back-of-pack labels (Talati *et al.* 2017b; Chantal *et al.* 2017). On the above, evaluative labels include all FOPLs which, through algorithms and treatment of quantitative information on the presence of nutrients, propose a qualitative evaluation of the product, expressing it in a synthetic form through images or symbols that are easy to interpret (e.g. through colors); by contrast reductive labels insert information regarding calories and

nutrients on the front of the packs, without pro- posing predefined interpretative evaluations of the effects of the product contents on nutrition and health, but limiting to provide relevant information in a clear way that will then be decoded and interpreted by the consumer.

Conceptual framework

We structure our design following the framework developed by Grunert and Wills (2007), one of the most utilised in past FOPL studies on consumers' understanding of nutrition information and subsequent food choices (Méjean *et al.* 2013, 2014; Ducrot *et al.* 2015a; Julia *et al.* 2015a, 2015b; Chantal *et al.* 2017; Egnell *et al.* 2018a, 2018b, 2019; Talati *et al.* 2019). The framework is articulated in the following phases: exposure, perception, understanding and liking, and use. Given the objectives of our study, we concentrate on consumer understanding and liking as consumers' responses to FOPL exposure and their ability to inform consumers on the nutritional values of foods. The framework introduces two types of understanding: subjective and objective.

Objective understanding requires the correct response to an information stimuli, compatible with the meaning that the sender intended to communicate, or, in other words, that a customer would attach a "more healthy" vs. "less healthy" meaning to a product characterised by a specific FOPL. On average, "summary labels" registered the highest performance regarding "objective understanding" (Hersey *et al.* 2013; Ducrot *et al.* 2015b; Egnell *et al.* 2018a, 2018b) since they are characterised by a synthesis of the main information and, in most of the cases, by the presence of colour, that is considered fundamental in capturing consumers' attention (Aschemann-Witzel *et al.* 2013; Hersey *et al.* 2013; Ducrot *et al.* 2015a, 2015b; Egnell *et al.* 2018b; Talati *et al.* 2019). However, due to the fact that these labels provide less information if com- pared with "nutrient-specific" ones, they are less trusted by consumers and less likely to be wanted as compulsory (Talati *et al.* 2019).

Subjective understanding, meanings that consumers derive from the perceived label information and the extent to which consumers believe they have understood the communication in a relevant way. It could serve as a basis to form consumers' opinions and thus an informed decision. Nutrient specific labels fit more with the concept of giving consumers "data-driven" information, empowering them to utilise information for their best use, according to varying consumption situations and occasions at single customer level. In this

respect, evaluative/interpretative labels register the highest degree of liking, trustworthiness and information fitness, while the most comprehensible are the Warning Labels (Talati *et al.* 2019). The main short- comings deriving from the usage of such systems regard the time consumption and the overall comprehensibility of the label itself (Hersey *et al.* 2013; Talati *et al.* 2017a).

Cross-country FOPL effectiveness

A relevant stream of recent academic research focused on comparing FOPLs effectiveness across countries to understand whether any FOPL presents a consistent superiority irrespective of socio-cultural differences and different degree of market presence. The topic is also a relevant element for the growing debate among governmental bodies at EU level (Radosavljevic and Foote 2020), a discussion which requires the backing of research evidences to inform potentially divergent positions. We anticipate that, to our knowledge, there is no uniform evidence of absolute "superiority" of one label over the others along all variables, as pre-condition to achieve the institutional desired goal of overweight and obesity reduction and supporting without any reasonable doubt changes in consumers' dietary habits.

According to the perspective of this paper, we concentrated on researches related to consumers' under- standing. In 2009, GDA/RI was tested in six countries showing differences in understanding and use (Grunert *et al.* 2010a). van Kleef and Dagevos (2015) studied attentional capture, processing time, purchase intention and perceived healthfulness, and the effect of colour in terms of salience of the stimuli. In 2018, 11 FOPLs were tested in Canada, the US, the UK and Australia, to understand symbols' effectiveness in communicating "high" level of critical nutrients in time-limited situation (Goodman *et al.* 2018). More recent studies focused on perception to include mandatory FOPL on products (Talati *et al.* 2019) and on the discrimination of food products (Dréano-Trécant *et al.* 2020).

With a specific focus on objective understanding, a study on 12 countries (Egnell *et al.* 2018b) showed how, irrespective of the socio-cultural contexts, the Nutri-Score performed better than Health Star Rating (HSR), Multiple-Traffic-Light (MTL), Reference Intake (RI) and Warning Labels (WL) in terms of ranking product categories on their nutritional quality and helping customers to discriminate among foods. A similar study has recently been replicated in Italy (Fialon *et al.* 2020). A subsequent study on the same countries, but on different variables – trust, liking, easy understanding and capability of providing needed information – showed how,

differently from previous cases, Multiple-Traffic-Light consistently over-per- formed other FOPLs, with Nutri-Score showing a lower performance in terms of comprehensibility, trustworthiness and completeness (Talati *et al.* 2019). Ares *et al.* (2018c) demonstrated that on one side "Warning Labels" had a significant effect on consumers' purchase intention for a larger share of products than Nutri-Score, on the other side, the Nutri-Score and the Health Star Rating increased the percentage of participants who regarded the products as healthful compared to nutritional Warnings Labels.

A widely uncovered area in terms of cross-country comparison is still related to subjective understanding, and the understanding of which FOPLs can better empower customers to take an informed decision. Extant analysis focus in fact on single countries (De la Cruz-Gongora *et al.* 2017; Vargas-Meza *et al.* 2019). For example, a study ion Italian consumers on a set of high consumption categories of pre-packaged foods in different "at-home" usage-occasions, showed the effectiveness of NutrInform Battery and the positive performance in being perceived by consumers as an informative FOPL in terms of understanding of the product composition (Mazzù *et al.* 2020).

A shift of focus in the tested variables might pro- duce different results. To our knowledge, thus, previous researches are lacking in providing consistent evidences that socio-cultural aspects might impact the superiority of FOPL in specific dimensions of consumer understanding. This study then contributes to the current research and institutional debate and to future research avenues in the perspective of subjective understanding, comparing FOPLs belonging to different nutritional labelling schemes, in multiple and diverse EU countries.

Research objectives

In the light of the above, we will then explore the impact, in terms of subjective understanding and liking, of two representative FOPLs, the "Nutrient Specific", non-directive enriched informative NutrInform Battery and the directive "Summary label" Nutri-Score in multiple countries. We will analyse (i) if Countries' performance differs in terms of FOPL subjective comprehension and likeability, i.e. if one of the two labels presents a consistently better performance than the other, and if the magnitude of the difference is comparable across countries, (ii) the specific main effects by-country, and (iii) if results are influenced by individuals' socio-demographics.

Tested countries vary in terms of official adoption of FOPL in own market, "position" of Country's Governmental Bodies, percentage of penetration of overweight and obesity in the population, "volume" of the public debate and discussion on FOPL and socio- cultural background.

3.3. Methods and materials

Stimuli

We conducted our research focussing on two labels representative of different ends in the spectrum of current FOPL categories: the brand-new NutrInform Battery in the area of "Nutrient Specific FOP" and the established Nutri-Score in the area of "Summary Labels". We selected NutrInform Battery FOPL also because, to our knowledge, this non-directive label has not yet been tested in any other study in EU countries, except for the study of Mazzù *et al.* (2020) which specifically focussed on Italian respondents. We then selected the directive Nutri-Score also for its aim at helping consumers choosing the healthiest alternative and encourage producers to reformulate their food products (Julia and Hercberg 2017). Among the various summary labels presented in the market, the Nutri-Score is one of the most frequently tested FOPL in the recent literature (Ares *et al.* 2018b; Egnell *et al.* 2018b; Finkelstein *et al.* 2019; Talati *et al.* 2019; Dréano-Trécant *et al.* 2020), obtaining in most of the cases the highest performance in terms of objective understanding and capability to allow respondents to rank food products in terms of their nutritional quality. Moreover, Nutri-Score is currently among the most adopted label in Europe, as it is presently applied in France, Belgium and Germany and intended to be adopted also in Netherlands, Spain and Luxembourg (European Parliaments and the Council 2020). Finally, despite the overall volume of "Front- of-Pack labelling" is quite low in social media, Nutri- Score showed up as among the most discussed key- words on this topic. An exploratory analysis on twitter highlights that Nutri-Score dominates the discussion on FOPL topic, as its volume of discussion is much higher vs. both other FOPL tested in past cross-country analysis e.g. Multiple-Traffic-Light, Warning Labels and Reference Intake) and vs. more generic keyword as FOP, FOPL, and Front-of-Pack.

Research Design

A between-subject design was used for this study, with two different conditions as stimuli: condition (1) with NutrInform Battery FOPL and condition (2) with Nutri-Score FOPL. In each country, respondents were exposed to one randomised condition (product stickered with a FOPL) only. This resulted in a 2 (Nutri-Score vs. NutrInform Battery) × 7 (tested countries), with a total of 14 different scenarios.

The decision to include mock products relies on the purpose to avoid brand and additional information influence on participants' perceptions of the products, in accordance with similar research (Arrúa *et al.* 2017; Pettigrew *et al.* 2017; Ares *et al.* 2018a; Egnell *et al.* 2018b). The mock packages were realised to resemble real food products in 4 alternative categories – yogurt, sauces, biscuits, and saltines - already tested in a previous research (Mazzù *et al.* 2020). The two FOPL variants covered approximately the same surface area on the package of products belonging to the same product category. Respondents saw also an enlarged version of FOPL in order to clearly read the information provided and answer to questions.

The study was carried out in seven countries – France, Germany, Greece, Italy, Portugal, Romania, Spain. To note, to the extent of our knowledge, no other study has already tested the effect of NutrInform Battery in terms of understanding and liking on the aforementioned countries. The selection of countries was based on a number of criteria: official adoption of FOPL in own market, "position" of Country's Governmental Bodies, percentage of penetration of overweight and obesity in the population, "volume" of the public debate and discussion on FOPL, and socio-cultural background. For the first criteria, at the time of field, one country (France) already had a FOPL system (Nutri-Score), another (Germany) was about to introduce a FOPL system (Nutri-Score), while all other tested countries did not have a specific FOP presence. Governmental institutions also have different positions towards different FOPL approaches: France, Germany and Spain in favour (already adopting or announcing to adopt) of the directive Summary Label "Nutri-Score"; Greece, Italy and Romania in favour of enriched informative Nutrient Specific systems (Radosavljevic and Foote 2020); Portugal as overall neutral in the debate. In terms of the third criteria, obesity index (Eurostat 2014), countries perform differently with Italy at 10.5%, France at 14.7%, Germany at 16.4%, Spain at 16.2%, Portugal at 16.1%, Romania at 9.1% and Greece at 16.9%. On the fourth criteria, an exploratory Twitter-based query analysis, with 15,832 geo-referenced tweets on a five months period from January to June 2020, analysed the presence of Nutri-Score as discussion topic and highlighted

its relevance in the debate in most of the tested countries. The fifth criteria is backed by evidences of different scores in the Dimension of National Culture (Hofstede Model 2011, 2020).

With the aim to contribute to the extant literature, this research then outlines evidences on the acceptance of the brand-new enriched informative Nutrient Specific system (NutrInform Battery) in terms of subjective understanding and liking in the seven afore- mentioned countries and compares results with one of the most tested and spread Summary Label (Nutri-Score).

Study population and data collection

A total of 2996 individuals from the 7 countries, namely France (FRA), Germany (GER), Greece (EL), Italy (ITA), Portugal (PT), Romania (RO) and Spain (ES), were recruited through Qualtrics XM platform, an international web panel provider, using demo- graphic quotas based on age and gender, representative of country's population. Details of sample size by country and socio-demographics information are pro- vided in Table 1. Participants were asked to complete an online survey and had been excluded if the quota bracket to which they belong, had been filled.

Respondents with a time response lower han 3 minutes were removed from the dataset (n = 220; 7.34% of the sample). The 2776 net respondents completed an online questionnaire which collected socio-demographic data before answering the questionnaire and expressing their opinion regarding FOPL on food products.

For each country, the survey was submitted in the local official language. Translation and adaptation was provided by professional mother-tongue translators. A soft launch of the survey was used to check consumers' acceptance and understanding of the questionnaire before full survey delivery. After having answered information concerning socio-demographic data, respondents in all countries had been randomly assigned to one of the different stimuli presented above, thus each respondent saw one of the four food product categories with one of the two alternative FOPL (NutrInform or Nutri-Score).

Subsequently, respondents were asked to read a brief description of FOPL meaning, and asked to answer questions aimed at measuring subjective understanding and liking of the label they saw.

Participants gave their informed consent for inclusion before they participated in the study.

Table 1. Details of sample size by country and socio-demographic information

	Italy		France		Germany		Spain		Portugal		Greece		Romania	
	N= 368		N=341		N=330		N= 440		N= 417		N= 440		N=440	
Variables	Group 1 (NutrInform Battery) (%)	Group 2 (Nutri-Score) (%)	Group 1 (NutrInform Battery) (%)	Group 2 (Nutri-Score) (%)	Group 1 (NutrInform Battery) (%)	Group 2 (Nutri-Score) (%)	Group 1 (NutrInform Battery) (%)	Group 2 (Nutri-Score) (%)	Group 1 (NutrInform Battery) (%)	Group 2 (Nutri-Score) (%)	Group 1 (NutrInform Battery) (%)	Group 2 (Nutri-Score) (%)	Group 1 (NutrInform Battery) (%)	Group 2 (Nutri-Score) (%)
Age														
18-24	6.3%	7.8%	7.0%	10.5%	3.6%	6.8%	6.4%	10.0%	11.2%	10.4%	15.9%	10.5%	10.9%	10.0%
25-34	11.4%	12.0%	12.9%	11.2%	12.4%	9.3%	18.2%	11.8%	16.0%	17.5%	19.1%	19.1%	16.8%	20.0%
35-49	24.4%	28.7%	22.2%	25.3%	27.4%	21.0%	26.4%	0,34	34.0%	33.7%	30.9%	33.6%	34.1%	34.1%
50-64	27.8%	23.4%	29.2%	25.9%	30.4%	27.7%	29.5%	29.1%	27.6%	29.9%	26.8%	27.3%	23.7%	24.5%
65+	30.1%	28.1%	28.7%	27.1%	26.2%	35.2%	19.5%	15.0%	11.2%	8.5%	7.3%	9.5%	14.5%	11.4%
Gender														
Men	48.3%	46.4%	49.7%	47.1%	41.7%	53.1%	56.8%	52.3%	48.1%	51.2%	51.7%	52.3%	48.6%	58.6%
Women	51.7%	53.6%	50.3%	52.9%	58.3%	46.9%	43.2%	47.7%	51.9%	48.8%	48.3%	47.7%	51.4%	41.4%
Education														
Lower than diploma	42.6%	45.8%	21.4%	33.3%	21.4%	13.0%	3.6%	4.5%	8.7%	8.1%	2.3%	2.4%	8.2%	10.0%
Diploma	44.3%	39.6%	50.0%	39.9%	56.5%	61.1%	42.8%	40.0%	47.1%	43.1%	26.8%	26.4%	30.9%	36.4%
Bachelor Degree	4.0%	2.1%	16.1%	17.9%	13.8%	11.1%	44.1%	41.4%	16.0%	15.1%	55.5%	56.0%	38.2%	40.5%
Master Degree	5.1%	9.9%	11.3%	6.1%	8.3%	13.6%	6.8%	7.7%	21.9%	26.1%	14.5%	13.7%	14.5%	6.7%
PhD	4.0%	2.6%	1.2%	2.8%	0.0%	1.2%	2.7%	6.4%	6.3%	7.6%	0.9%	1.5%	8.2%	6.4%
Occupation														
Full-time job	32.4%	29.7%	32.1%	34.1%	38.7%	29.6%	41.8%	45.9%	54.4%	58.3%	38.8%	40.9%	59.5%	54.1%
Part-time job	19.8%	7.8%	7.0%	6.5%	11.9%	12.3%	6.4%	10.5%	5.8%	0,07	14.2%	13.2%	4.5%	3.6%
Unemployed	10.8%	12.0%	7.5%	14.1%	1.8%	1.9%	12.7%	10.9%	6.8%	7.6%	26.0%	19.1%	5.0%	3.6%
Student	3.4%	4.2%	7.6%	3.5%	3.0%	6.2%	4.5%	6.8%	5.8%	4.8%	0.0 %	13.6%	2.7%	5.5%
Retired	28.4%	24.4%	34.7%	31.2%	29.1%	37.0%	19.5%	15.0%	15.0%	10.9%	7.7%	3.6%	17.8%	17.3%
Housewife	9.7%	15.1%	4.1%	5.3%	8.9%	5.6%	8.2%	4.5%	0.5%	0.9%	4.5%	9.1%	3.6%	6.8%
Self-employed	4.5%	6.3%	4.7%	2.4%	4.8%	6.2%	5.5%	5.9%	11.7%	10.4%	8.8%	0.5%	6.9%	8.2%
Unable to work	0.0%	0.5%	2.3%	2.9%	1.8%	1.2%	1.4%	0.5%	0.0%	0.5%	0.0%	0.0%	0.0%	0.9%
Income														
<20,000	47.7%	40.1%	39.2%	45.9%	26.8%	34.0%	50.0%	40.5%	56.3%	58.8%	77.3%	74.1%	77.3%	84.1%
20,000-40,000	35.3%	44.8%	39.8%	37.6%	37.5%	31.5%	40.0%	40.9%	30.1%	31.3%	21.4%	22.3%	14.1%	10.5%
41,000-60,000	11.4%	8.3%	11.1%	11.2%	18.4%	16.7%	7.7%	14.5%	11.1%	7.6%	0.8%	2.7%	4.5%	3.1%
61,000-80,000	2.3%	4.2%	4.1%	2.9%	11.9%	11.7%	1.4%	2.3%	1.0%	1.4%	0.0%	0.4%	1.8%	1.4%
81,000-100,000	2.3%	1.0%	1.7%	1.2%	3.0%	3.7%	0.9%	0.9%	0.5%	0.9%	0.5%	0.5%	1.8%	0.5%
>100,000	1.1%	1.6%	4.1%	1.2%	2.4%	2.5%	0.0%	0.9%	1.0%	0.0%	0.0%	0.0%	0.5%	0.5%

Constructs and measures

The dimension of subjective understanding is constituted by the following sub-measures: (a) comprehensibility design, (b) help-to-shop, (c) complexity. We also add a specific set of measure for (d) liking. In line with the items tested in past researches (Mazzù *et al.* 2020), we will utilise a set of measures all present and derived from extant literature, and pre-validated in terms of their reliability also for this study. Specifically:

- *Comprehensibility/design* items, rated through (Möser *et al.* 2010): "I feel well informed by the food label", "This label is believable and trust- worthy" and "This label is easy to interpret" (α= 0.879);
- *Help-to-shop* items, rated through (Möser *et al.* 2010): "This label helps me to understand the product composition", "This label helps me to understand different nutritional values", "This label makes it easier to choose food" (α = 0.895);
- *Complexity* reduction items, rated through (Möser *et al.* 2010): "The food label is rather extensive", "Using this food label to choose foods is better than just relying on my own knowledge about what is in them" (α = 0.841).

- *Liking*, measured asking participants: “How do you evaluate the label?”. Respondents expressed their opinion answering to the following scales: “bad/ good”, “unfavourable/favourable” and “negative/ positive” (Allen and Janiszewski 1989) (α=0.938).

Consumers were asked to rate their assessment on all dimensions through a seven-point Likert scale.

Statistical analysis

Data obtained from participants’ results have been analysed using IBM SPSS Statistics (version 25, SPSS Inc., Chicago, IL, USA). After evaluating the reliability to assess the scale consistency, we calculated and graphed the means for the subdimension of subjective understanding (comprehensibility design, help-to-shop and complexity) and for liking in each country.

A 2 (FOPL condition) × 7 (Country) Analysis of covariance (ANCOVA) was conducted to test whether the means of each dependent variable (comprehensibility, help-to-shop, complexity and liking) are equal across levels of the categorical independent variables (FOPL and Country), while statistically controlling for the effects of three variables, such as age, level of income and education level. The interaction between FOPL and country, while controlling for age, level of education and income has been included as an independent variable. Contrasts among FOPLs and countries were performed with a Bonferroni correction for multiple comparisons applied to dimension to delving into mean differences of each FOPL across countries. The estimated marginal means for the different FOPLs and the FOPL by country interactions were graphed for all the dependent variables where a significant main effect of FOPL or interaction between FOPL and country was observed.

We included control variables in line with extant literature findings (Egnell *et al.* 2018b; Talati *et al.* 2019). Indeed, former studies highlighted miscellaneous performances due to differences in socio-demo- graphic characteristics of respondents, related to: (a) age, (b) education, and (c) income level. Concerning age, studies that consider children and adults as respondents, highlighted a significant higher preference among children towards summary/evaluative FOPLs (Talati *et al.* 2016; Pettigrew *et al.* 2017), while more heterogenous results were found across adults and regarding elderly people, they are generally less inclined

to collect new information from FOPL and to use it to improve their knowledge (Thiene *et al.* 2018). Moreover, different education levels might impact FOPL understanding, since the capacity of decoding nutritional information is a function of the education and lower education level could negatively impact on FOPL understanding (Grunert *et al.* 2010b; Julia *et al.* 2015b). This is particularly evident in studies involving nutrient-based FOPL, as for example RI, since they are characterised by more complex information, which request a higher cognitive workload to be interpreted (Campos *et al.* 2011; Hawley *et al.* 2013; Hersey *et al.* 2013; Méjean *et al.* 2013; Gregori *et al.* 2014; Ducrot *et al.* 2015a; Egnell *et al.* 2018b). Similar results have been highlighted in case of low income level which is correlated with preference of consumers for more evaluative/directive labels (Vargas-Meza *et al.* 2019) and lower level of use of nutrition information (Grunert *et al.* 2010a, 2010b).

We ran a series of independent t-test in each country to analyse the magnitude of the difference between the two FOPL on the four examined dimensions.

Finally, with the aim of understanding whether the performance of each FOPL varies across countries, a 1 x 7 one-way Analysis of Variance (ANOVA) was then carried out separately for NutrInform Battery and Nutri-Score on each tested dependent variable.

3.4. Results

FOPL performance – descriptive statistics by country

In the following paragraph, we report the mean performance of NutrInform Battery and Nutri-Score in each tested country. In France, the NutrInform Battery reports a mean of 4.92 vs. 4.62 of Nutri-Score in terms of comprehensibility, which reflects how much respondents consider the label to be able to inform, to be believable and easy to understand; 4.27 vs. 4.82 for the help-to-shop variable, which measures the label's ability to help customers understand product composition and make related decisions; 4.67 vs 4.07 for complexity, which reflects the extent of the label's information. On the contrary, according to the French sample, the variable liking scores a mean that is higher for the Nutri-Score label, namely 5.05 vs. 4.89 of NutrInform Battery. This result occurs only in the aforementioned country, but it is not statistically significant. In Germany, the comprehensibility is higher for the Battery than the Nutri-Score, namely the former reports a mean of 5.2 vs. 4.66. For the help-to-shop the mean is 5.08 vs. 4.23, for complexity 4.8 vs. 4.2 and for liking 4.95 vs. 4.8. In Greece, the NutrInform scores a

mean of 5.08 vs. 4.06 of the Nutri-Score in terms of comprehensibility. Help-to-shop (4.9 vs 3.8), complexity (4.5 vs. 3.5) and liking (4.77 vs. 4.48) present a similar behavior. All report mean differences which are higher for the NutrInform Battery. In Italy, the NutrInform Battery reports a mean of 5.06 vs. 4.4 of the Nutri-Score for the comprehensibility; 5.09 vs. 4.09 for help-to-shop; 4.81 vs 3.78 for complexity; and 5.07 vs. 4.47 for liking. In Portugal, comprehensibility is higher for NutrInform Battery than the Nutri-Score (5.02 vs. 4.24), and same for help-to-shop (5.1 vs. 3.9); complexity (4.6 vs. 3.5) and liking (5.04 vs. 3.45). In Romania, the NutrInform comprehensibility scores a mean of 5.35 vs. 4.84 of Nutri-Score, 5.4 vs. 4.8 for the help-to-shop, 5.07 vs. 4.2 for the complexity and 5.3 vs. 5.2 for liking. In Spain, the comprehensibility is 5.03 for the NutrInform vs. 4.58 for the Nutri-Score, the NutrInform help-to-shop is 5.06 vs. 4.2, complexity is 4.65 vs. 3.76 and liking 4.95 vs. 4.7.

FOPL-country interaction effect

We validated our results using a between-subjects two-way ANCOVA for each dependent variable (comprehensibility, help-to-shop, complexity and liking), while controlling for age, education and income. We present results starting from the three dimensions of subjective understanding and then we conclude with liking (Table 2).

Table 2. Results of the two-way Analysis of Covariance (ANCOVA)

	Comprehensibility						*Help-to-shop*						*Complexity*						*Liking*					
Predictor	***SS***	***df***	***MS***	***F***	***p***	η^2	***SS***	***df***	***MS***	***F***	***p***	η^2	***SS***	***df***	***MS***	***F***	***p***	η^2	***SS***	***df***	***MS***	***F***	***p***	η^2
Front-of-pack label (A)	276.32	1	276.32	124.315	***	0.043	541.256	1	541.256	217.596	***	0.073	516.93	1	516.93	190.52	***	0.065	32.014	1	32.014	14.853	***	0.005
Country (B)	75.721	6	12.62	5.678	***	0.012	150.799	6	25.133	6.311	***	0.022	139.277	6	23.213	8.56	***	0.018	91.325	6	15.221	7.062	***	0.015
Front-of-pack label x Country (A x B)	39.853	6	6.642	2.988	**	0.006	27.494	6	4.582	1.842		0.004	27.069	6	4.511	1.66		0.004	32.476	6	5.413	2.511	***	0.005
Age	7.201	1	7.201	3.24		0.001	33.203	1	33.203	13.348	***	0.005	57.278	1	57.278	21.11	***	0.008	5.835	1	5.835	2.707		0.001
Level of education	8.035	1	8.035	3.615	*	0.001	15.698	1	15.698	7.519	*	0.002	36.253	1	36.253	13.36	***	0.005	9.442	1	9.442	4.38	*	0.002
Income	26.965	1	26.965	12.132	**	0.004	20.306	1	20.306	10.104	**	0.003	22.879	1	22.879	8.43	***	0.003	22.290	1	22.29	10.341	***	0.004
Error	6110.33	2749					6837.955	2749					7458.614	2749					5925.29	2749				

Comprehensibility: R^2 = .068; Help-to-shop: R^2 = .099; Complexity: R^2 = .099; Liking: R^2 = .030
SS: Sum of squares; df: degrees of freedom; MS: mean square; F: F-test; η2: effect size; *p<0.05; **p<0.01; ***p < 0.001
Age, Level of education and Income are covariates

As shown in the Table 2, considering comprehensibility as the dependent variable and FOPL system (0=Nutri-Score; 1=NutrInform Battery), country and their interaction, as independent variables while controlling for age, education and income, the control variables show significant associations with comprehensibility except for age (F(1, 2749) = 3.240, p=0.072). The ANCOVA also showed that there is a significant main effect of NutrInform Battery on comprehensibility ($M_{NutrInform}$ = 5.11 vs. $M_{Nutri\text{-}Score}$ = 4.47; F(1, 2749) = 124.315, p=0.000). Regarding the main effect of the country on the comprehensibility, we found it to be statistically significant (M_{Greece} = 4.65; M_{Spain}= 4.80; M_{France} = 4.70; $M_{Germany}$= 4.82; M_{Italy} = 4.66; $M_{Portugal}$ = 4.75; $M_{Romania}$ = 5.16; F(6,2749)=5.678, p=0.000). Further, there was a statistically significant

interaction between FOPL system and Country on comprehensibility, whilst controlling for age, income and education (F(6, 2749) = 2.988, p=0.007). In order to better examine such a moderating influence, we controlled for planned contrast. It proved that according to the NutrInform Battery, across all the countries, respondents are more likely to consider the label to be able to inform, to be believable and easy to understand ($M_{NutrInform}$ = 5.11 vs. $M_{Nutri\text{-}Score}$ = 4.47; F(1, 2749) = 124.315, p=0.000). Similarly, a two-way ANCOVA was carried out to test whether significant effects of FOPL system exist (NutrInform vs. Nutri-Score), country and their interaction on help-to-shop, controlling for age, education level and income. The results suggest that there is a statically significant effect of FOPL system on help-to-shop, which measures the label's ability to help customers understand product composition and make related decisions ($M_{NutrInform}$ = 5.06 vs. $M_{Nutri\text{-}Score}$= 4.17; F(1,2749)=217,596, p=0.000). Also, a significant effect of the country on the dependent variable has been outlined (M_{Greece} = 4.46; M_{Spain}= 4.63; M_{France} = 4.46; $M_{Germany}$= 4.53; M_{Italy} = 4.5; $M_{Portugal}$ = 4.55; $M_{Romania}$ = 5.16; F(6,2749)=6.311, p=0.000). A significant interaction effect between FOPL system and Country has not been found (F(6, 2749) = 1.842, p=0.087)[17]1. Delving into these outputs, we performed contrasts which showed that there is a statistically significant mean difference between NutrInform Battery and Nutri-Score in each country (F(1,2749)=217.596; p=0.000).

As regards to complexity, the two-way ANCOVA showed a significant main effect of FOPL system (F(1,2749)=190.523; p=0.000), Country (F(6,2749)=8.555; p=0.000) and the covariates age (F(1,2749)=21.111; p=0.002), education level (F(1,2749)=13.362; p=0.000) and income (F(1,2749)=8,432; p=0.002). As regards to the interaction between FOPLs and Country we found it not to be statistically significant (F(6,2749)=1.663, p=0.290)[18]2. The mean of NutrInform ($M_{NutrInform}$ = 4.72) is higher than the one of Nutri-Score ($M_{Nutri\text{-}Score}$ = 3.85; F(1, 2749) = 190.523, p=0.000). Thus, NutrInform Battery shows a better performance in terms of complexity irrespective of the country analysed.

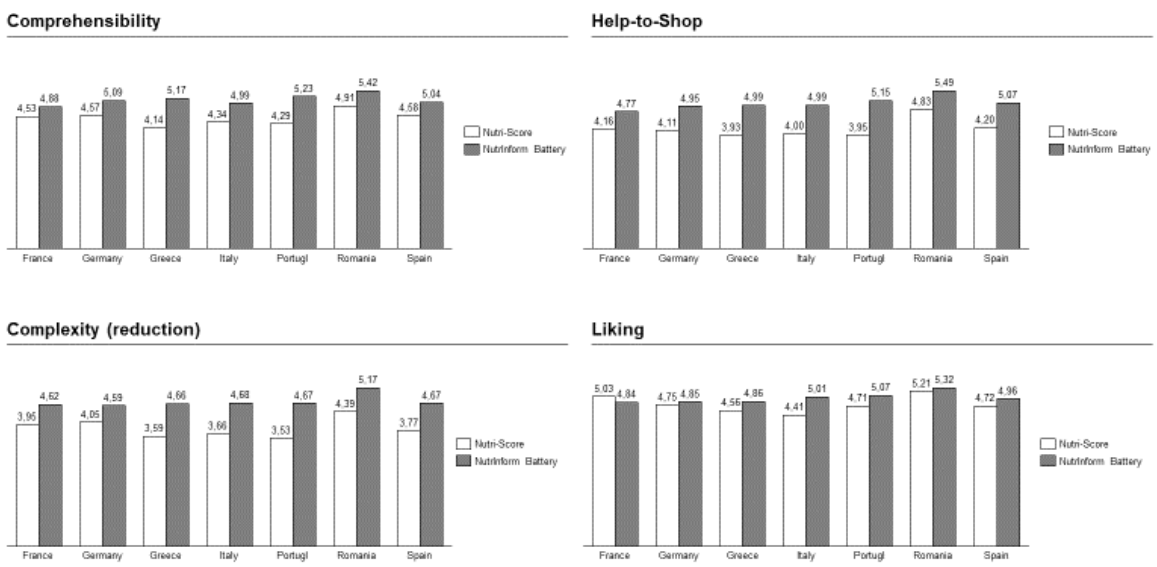
Controlling for age, level of education and Income, a two-way ANCOVA also proved variance's heterogeneity on liking. First, the effects of the education level (F(1, 2749) = 4.380, p=0.036) and income (F(1, 2749) = 10.341, p=0.001) were statistically significant. Further, the

[17] To test whether exists a significant interaction on the items of the help-to-shop variable, we repeated the two-way Ancova controlling for age, education and income on each single measure. Results suggest there is a significant interaction effect only regarding the label "This label helps me to understand different nutritional values" (F(6,2749)=3,112; p=0.005). The interaction between FOPLs and country for the items "This label helps me to understand the product composition" (F(6,2749)= 1,290; p=0.258) and "This label makes it easier to choose food" (F(6,2749)= 1,464; p=0.187) is not significant.

[18] To test whether exists a significant interaction on the items of Complexity, we ran a two-way Ancova on each single measure. Results suggest there is no interaction in all the subdimensions of the construct. The label "The food label is rather extensive" does not present a significant interaction effect (F(6,2749)=1.201; p=0.302) and, similarly, the label "Using this food label to choose foods is better than just relying on my own knowledge about what is in them" (F(6,2749)=1.756; p=0.104).

analysis revealed that there is a significant main effect of FOPL system on the liking ($M_{NutrInform}$ = 4.99 vs. $M_{Nutri\text{-}Score}$= 4.76; F(1, 2749) = 14.853, p=0.000). Furthermore, there was a significant main effect for the country on liking ((M_{Greece} = 4.70; M_{Spain}= 4.84; M_{France} = 4.93; $M_{Germany}$= 4.79; M_{Italy} = 4.70; $M_{Portugal}$ = 4.89; $M_{Romania}$ = 5.26; F(6,2749)=7.062, p=0.000). Also, we found a significant interaction between the FOPL system (Nutri-Score vs. NutrInform) and the country on liking, whilst controlling for age, education and income (F (6, 2749) = 2.511, p=0.02). Planned contrast showed that there is a statistically significant difference (MD=0.217; SD = 0.056) between the NutrInform Battery's liking and Nutri-Score (F(1, 2749) = 2.155, p=0.000). A synthesis of the adjusted mean is presented in Figure 1.

Figure 1. Mean scores by Country on comprehensibility, help-to-shop, complexity (reduction) and liking items for Nutri-Score and NutrInform Battery FOPLs adjusted for age, education, income status



By country analysis – NutrInform Battery vs. Nutri-Score

According to the present study in all tested countries, NutrInform Battery performed significantly better than the Nutri-Score in terms of subjective understanding, showing some variability in terms of liking. We illustrate the results of the independent t-test to validate the magnitude of the differences between the two FOPLs. In France, the NutrInform Battery reports a directionally better performance than the Nutri-Score on comprehensibility (t(339)=1.84; p=0.066), and a significantly better performance on help-to-shop (t(339)=3.15; p<0.01) and complexity (t(339)=3.37; p<0.01). On the contrary, the variable liking presents a not

statistically significant higher mean for the Nutri-Score ($t(339)=1.03$; $p=0.303$). In Germany, the comprehensibility is statistically higher for the NutrInform Battery vs. the Nutri-Score, ($t(328)=3.31$; $p<0.01$). A similar situation can be observed for help-to-shop ($t(328)=4.80$; $p<0.01$) and complexity ($t(328)=3.09$; $p<0.01$), while mean difference in liking is not significant ($t(328)=0.70$; $p=0.481$). In Greece, the NutrInform Battery reports significant mean differences vs. Nutri-Score on all four dependent variables. Specifically, comprehensibility ($t(438)=7.2$; $p<0.01$), help-to-shop ($t(438)= 7.04$; $p<0.01$), complexity ($t(438)= 6.84$; $p<0.01$) and liking ($t(438)=2.18$; $p<0.05$). In Italy, all tested dimensions vary significantly, with NutrInform Battery performing better than the Nutri-Score for comprehensibility ($t(366)=4.09$; $p<0.01$), help-to-shop ($t(366)=5.78$; $p<0.01$), complexity ($t(366)=5.78$; $p<0.01$), and liking ($t(366)=3.50$; $p<0.01$). In Portugal, comprehensibility is statistically higher in NutrInform Battery vs. Nutri-Score ($t(415)=7.03$; $p<0.01$). A similar performance is also present in help-to-shop ($t(415)=8.50$; $p<0.01$), Complexity ($t(415)=7.52$; $p<0.01$) and liking ($t(415)=11.02$; $p<0.01$). In Romania, the NutrInform shows a significantly higher mean than Nutri-Score for comprehensibility ($t(438)=3.51$; $p<0.01$), help-to-shop ($t(438)=4.46$; $p<0.01$), complexity ($t(438)=4.73$; $p<0.01$), but not for liking ($t(438)=0.80$; $p=0.421$). In Spain, in all tested variables, NutrInform Battery performed better than Nutri-Score. Specifically, on comprehensibility ($t(438)=3.02$; $p<0.01$), help-to-shop ($t(438)=5.57$; $p<0.01$), complexity ($t(438)=5.46$; $p<0.01$) and liking ($t(438)=1.58$; $p=0.115$). According to the present study in all countries NutrInform Battery performed significantly better than the Nutri-Score in terms of subjective understanding.

Subjective understanding and liking across country

With the aim of understanding whether the performance of each FOPL varies across countries, a 1 x 7 one-way Analysis of Variance (ANOVA) was then carried out separately for NutrInform Battery and Nutri-Score on each tested dependent variable.

Comprehensibility

In the case of NutrInform Battery, results ($F(6, 1374) = 2.120$, $p<0.05$) showed that at least one country presents a statistically significant different mean vs. other countries. Post-hoc analysis highlighted that the only significant variance is present between Romania and France ($MD=0.4290$, $p<0.05$). A significant main effect of the country ($F(1, 1388) = 5.784$, $p<0.001$) occurred also on the Nutri-Score. In this case, Romania positively differs from Greece

(MD=0.7760; $p<0.001$) and Portugal (MD=0.5995; $p<0.001$) and, Greece from Spain (MD=0.5150; $p<0.05$), France (MD=0.5531; $p<0.05$), and Germany (MD=0.5987; $p<0.05$). All the rest are not significantly different.

Help-to-shop

Similar results are present also for this dependent variable. The country is a significant predictor of the help-to-shop in both FOPL ($F_{NutrInformBattery}$ (1,1374) = 3.659, $p<0.001$; $F_{Nutri\text{-}Score}$ (1, 1388) = 6.748, $p<0.001$)). According to the contrasts, for NutrInform Battery help-to-shop, only Romania significantly differs from the other countries, with variability present on Romania-Greece (MD = 0.5348, $p<0.05$) and Romania-France (MD = 0.5977, $p<0.05$). For the Nutri-Score, the differences are significant between Romania-Greece (MD = 0.9121, $p<0.05$), Romania-Spain (MD = 0.5591, $p<0.05$), Romania-Italy (MD = 0.6619, $p<0.05$) and Romania-Portugal (MD = 0.8681, $p<0.05$).

Complexity

Results highlight that the country significantly predicts both NutrInform Battery (F(6, 1374) = 2.850, $p<0.05$) and Nutri-Score complexity (F(1, 1388) = 7.506, $p<0.001$). For NutrInform Battery, mean differences are significant only in Romania, as testified by the contrasts Romania-Greece (MD = 0.5477, $p<0.05$) and Romania-Portugal (MD = 0.4611, $p<0.05$). Nutri-Score wise, multiple differences in contrast exist mainly connected to Romania (Romania-Greece (MD = 0.8273, $p<0.05$); Romania-Spain (MD = 0.5432, $p<0.05$); Romania-Portugal (MD = 0.8519, $p<0.05$)), Greece (Greece-France (MD = 0.5933, $p<0.05$); Greece-Germany (MD = 0.7203, $p<0.05$), and Portugal (Portugal-France (MD=-0.6180, $p<0.05$); Portugal-Germany (MD=-0.7449, $p<0.05$)).

Liking

NutrInform Battery and Nutri-Score significantly vary across countries ($F_{Nutri\text{-}Score}$ (1, 1388) = 5.817, $p<0.001$); $F_{NutrInformBattery}$ (1,1374) = 2.643, $p<0.05$). According to the contrast, NutrInform Battery means differ in the pair Romania-Greece (MD = 0.4876, $p<0.05$) and Nutri-Score in Romania-Greece (MD = 0.6665, $p<0.05$), Romania-Italy (MD = 0.6757, $p<0.05$), Romania-Portugal (MD = 0.4844, $p<0.05$), and Greece-France (MD=-0.5724; $p<0.05$).

3.5. Discussion

This study explored consumers' *subjective understanding* and *liking* of the enriched-informative FOPL NutrInform Battery and the summary FOPL Nutri-Score across seven European countries. Tested countries have been selected on a number of criteria: official adoption of FOPL in own market, position of Country's Governmental Bodies, percentage of penetration of overweight and obesity in the population, volume of the public debate and discussion on FOPL, and socio-cultural background.

Results highlight that a significant effect exists in the interaction between Country and FOPLs on comprehensibility and liking, while controlling for covariates. On help-to-shop and complexity results show only a main effect of FOPLs on the dependent variable, without any significant interaction with the countries. It suggests that the NutrInform Battery, in terms of help-to-shop and complexity, relies on a positive assessment of European consumers, irrespective of the cross-cultural differences.

Subsequently, although the NutrInform Battery reached higher means in each country for the investigated variables (unless in France in the case of liking, which is not significant), the label outperformed in Romania. The aforementioned country in comparison to France (comprehensibility and help-to-shop), Greece (help-to-shop, complexity, liking) and Portugal (complexity) reached significant positive mean differences which reflect the higher consumers' evaluation according to the FOPL. We signal no other differences in terms of NutrInform Battery performance among countries, implying a constant effectiveness of the label in different socio-cultural backgrounds. The effectiveness of NutrInform Battery could then be considered stable across the European sample, except for Romania which relies on a greater attitude towards the two FOPLs. Indeed, the results are not heterogeneous, showing a common pattern in terms of comprehensibility, help-to-shop, complexity and liking across the countries despite the potential socio-cultural aspects which distinguish them.

Nutri-Score presents a similar situation for Romania, with higher mean performance in comparison to Greece (comprehensibility, help-to-shop, complexity and liking), Italy (help-to-shop, liking), Portugal (all dimensions), and Spain (help-to-shop, complexity). In addition, differences are also present in the performance of Greece in comparison to France (comprehensibility, complexity and liking), Germany (comprehensibility, complexity) and

Spain (comprehensibility); and Portugal in comparison to France (complexity) and Germany (complexity), signalling a much higher variability across countries in terms of subjective understanding and liking.

A subsequent analysis by-country, signals the presence of a significant differential performance of the two FOPLs. In all countries, NutrInform Battery showed a consistent and greater effectiveness vs. Nutri-Score on comprehensibility, help-to-shop and complexity. Regarding liking, NutrInform Battery was significantly the most favourably appreciated label in Italy, Greece, Portugal. The difference of means was not significant in France, where Nutri-Score outperformed NutrInform Battery, and Germany, Romania and Spain where, on the contrary, NutrInform Battery was preferred to Nutri-Score. The highest results among French respondents for Nutri-Score could be related to the fact that the FOPL is highly penetrated and customers are used to see it in front of the package of the products in the supermarket during the product selection phase and at home during product consumption. Indeed, as mentioned in a previous study (van Herpen *et al.* 2012) familiarity with a FOPL can influence self-reported evaluations.

In terms of subjective comprehension, NutrInform Battery had then been positively evaluated as it provided the information in an extensive and easy way and it was considered helpful in understanding product composition and different nutritional values. These results confirmed what demonstrated in previous studies, where consumers perceived that more information is better (Dana *et al.* 2019; Talati *et al.* 2019) and they trusted more FOPLs that were not summary-based (Talati *et al.* 2019)[19].

Moreover, it could be of interest to verify if the various institutional positions regarding the FOPL adoption that characterise each country, influence how these labels are perceived and appreciated by consumers. Indeed, differences in performance of FOPL across countries may be related to some extent also to the local context (Egnell *et al.* 2018b) and the influence of public discussion on nutrition and labelling issues. Further research should also be conducted adding other FOPLs currently present on the market, as for example MTL or Warning Labels, to explore in more detail, the different perceptions that can emerge in relation to the different aims of FOPLs.

[19] In some cases the abundance of information does not necessarily lead to more rational decisions, as information might be superior to individuals processing capacity (Lugli, 2018)

Our last level of the analysis evidenced some differences in terms of effectiveness according to the socio-demographics. In line with the extant literature, our results highlight there is a main effect of education and income level on subjective understanding and liking, with age specifically on complexity.

These results added interesting insights regarding the literature of FOPL perception among respondents from different countries, focussing on two labels that, to the extent to our knowledge, have not been fully analysed in terms of subjective understanding across-countries.

However, some limitations of the study should be recognised. Experimental process did not allow participants to have access to back-of-pack information regarding the nutritional composition of the products used in the study and they do not have any tactile experiences as in real life settings, as supermarkets. However, back-of-pack information is rarely used during real shopping situations (Van Kleef *et al.* 2008; Grunert *et al.* 2010a; Chantal *et al.* 2017), where other relevant aspects can have effect on consumers' evaluations. Moreover, subjective understanding and liking are just two dimensions that influence consumers' reactions to FOPL. Future research should therefore focus also on other important dimensions that influence consumer behaviour, as evaluation and choice.

Since the results showed the effectiveness of NutrInform Battery in terms of subjective understanding and liking, future researches could deepen other relevant aspects such as the influence on the willingness-to-buy at retail level, on Perceived Healthiness and on whether the NutrInform Battery could influence away-from-home behaviours promoting a healthier pattern or the overall effect in terms of objective understanding. Furthermore, the incidence of sociocultural aspects which affect the individuals' information processing could be deepened according to the attitudes to the FOPLs. Also, verify whether a preliminary introduction and description of the NutrInform Battery modify the respondents' evaluation.

3.6. Conclusion

In conclusion, regarding subjective comprehension and liking, NutrInform Battery emerged as more effective than Nutri-Score in allowing consumers understand information in a relevant way. It appeared to be understood in a clear way across the various countries, showing limited impact of socio-cultural differences among countries and outweighing potential familiarity of consumers with Nutri-Score in selected countries where the FOPL label is already part of

consumers' daily experience. Moreover, except for France where Nutri-Score presented a higher mean, yet not significant, than NutrInform Battery in terms of liking, NutrInform Battery emerged as the preferred label on subjective understanding within and across each country examined. Policy makers should be encouraged to implement comparative studies including subjective understanding to promote food education among consumers and NutrInform Battery to guarantee an informed selection and implementation of the most efficient and useful scheme, while deep diving their effectiveness in different socio-economical and health-related segments of the population.

References

Allen CT, Janiszewski CA. (1989). Assessing the role of contingency awareness in attitudinal conditioning with implications for advertising research. *J Market Res.* 26(1): 30–43.

Ares G, Aschemann-Witzel J, Curutchet MR, Antúnez L, Machín L, Vidal L, Martinez J, Giménez A. (2018a). Nutritional warnings and product substitution or abandonment: policy implications derived from a repeated purchase simulation. *Food Qual Prefer*. 65: 40–48.

Ares G, Aschemann-Witzel J, Curutchet MR, Antúnez L, Moratorio X, Bove I. (2018b). A citizen perspective on nutritional warnings as front-of-pack labels: insights for the design of accompanying policy measures. *Public Health Nutr.* 21(18):3450–3461.

Ares G, Varela F, Machín L, Antúnez L, Giménez A, Curutchet MR, Aschemann-Witzel J. (2018c). Comparative performance of three interpretative front-of-pack nutri tion labelling schemes: insights for policy making. *Food Qual Prefer.* 68:215–225.

Arrúa A, Vidal L, Antúnez L, Machın L, Martınez J, Curutchet MR, Giménez A, Ares G. (2017). Influence of label design on children's perception of 2 snack foods. *J Nutr Educ Behav.* 49:211–217.e1.

Aschemann-Witzel J, Grunert KG, van Trijp HC, Bialkova S, Raats MM, Hodgkins C, Wasowicz-Kirylo G, Koenigstorfer J. (2013). Effects of nutrition label format and product assortment on the healthfulness of food choice. *Appetite*. 71:63–74.

Barreiro-Hurle J, Gracia A, De-Magistris T. (2010). Does nutrition information on food products lead to healthier food choices? *Food Policy*. 35:221–229.

Campos S, Doxey J, Hammond D. (2011). Nutrition labels on pre-packaged foods: a systematic review. *Public Health Nutr.* 14(8):1496–1506.

Chantal J, Hercberg S., World Health Organization (2017). Development of a new front-of-pack nutrition label in France: the five-colour Nutri-Score. *Public Health Panorama*. 03:712–725.

Dreano-Trecant L, Egnell M, Hercberg S, Galan P, Soudon J, Fialon M, Touvier M, Kesse-Guyot E, Julia C. (2020). Performance of the front-of-pack nutrition label nutriscore to discriminate the nutritional quality of foods products: a comparative study across 8 European countries. *Nutrients*. 12(5):1303.

Dana LM, Chapman K, Talati Z, Kelly B, Dixon H, Miller C, Pettigrew S. (2019). Consumers' views on the importance of specific front-of-pack nutrition information: a latent profile analysis. *Nutrients*. 11:1158.

Ducrot P, Méjean C, Julia C, Kesse-Guyot E, Touvier M, Fezeu L, Hercberg S, Péneau S. (2015a). Effectiveness of front-of-pack nutrition labels in French adults: results from the NutriNet-Sante cohort study. *PLoS One*. 10: e0140898.

Ducrot P, M´ejean C, Julia C, Kesse-Guyot E, Touvier M, Fezeu LK, Hercberg S, Péneau S. (2015b). Objective under- standing of front-of-package nutrition labels among nutritionally at-risk individuals. *Nutrients*. 7:7106–7125.

Egnell M, Ducrot P, Touvier M, Alles B, Hercberg S, Kesse- Guyot E, Julia C. (2018a). Objective understanding of Nutri-Score Front-Of-Package nutrition label according to individual characteristics of subjects: comparisons with other format labels. *PLoS One*. 13(8):e0202095

Egnell M, Talati Z, Hercberg S, Pettigrew S, Julia C. (2018b). Objective understanding of front-of-package nutrition labels: an international comparative experimental study across 12 countries. *Nutrients*. 10:1542.

Egnell M, Talati Z, Gombaud M, Galan P, Hercberg S, Pettigrew S, Julia C. (2019). Consumers' responses to front-of-pack nutrition labelling: results from a sample from The Netherlands. *Nutrients*. 11:1817.

EU Regulation. 2011. Regulation (EU) No 1169/2011 of the European Parliament and of the Council of 25 October 2011. OJ. L 304:18–63.

European Commission. 2020. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of

the Regions a Farm to Fork Strategy for a fair, healthy and environmentally-friendly food system. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri= CELEX:52020DC0381

European Parliaments and the Council. 2020. Report from the Commission to the European Parliament and the Council regarding the use of additional forms of expression and presentation of the nutrition declaration. https://ec.europa.eu/food/sites/food/files/safety/docs/label- ling-nutrition_fop-report-2020-207_en.pdf

Eurostat 2014. Overweight and obesity - BMI statistics. https://ec.europa.eu/eurostat/statistics-explained/index. php?title=Overweight_and_obesity_-_BMI_statistics.

Fialon M, Egnell M, Talati Z, Galan P, Dréano-Trécant L, Touvier M, Pettigrew S, Hercberg S, Julia C. (2020). Effectiveness of different front-of-pack nutrition labels among Italian consumers: results from an online randomized controlled trial. *Nutrients*. 12:2307.

Finkelstein EA, Ang FJL, Doble B, Wong WHM, van Dam RM. (2019). A randomized controlled trial evaluating the relative effectiveness of the Multiple Traffic Light and Nutri-score front of package nutrition labels. *Nutrients*. 11(9):2236.

Finkelstein EA, Khavjou OA, Thompson H, Trogdon JG, Pan L, Sherry B, Dietz W. (2012). Obesity and severe obes ity forecasts through 2030. *Am J Prev Med*. 42:563–570.

Goodman S, Vanderlee L, Acton R, Mahamad S, Hammond D. (2018). The impact of front-of-package label design on consumer understanding of nutrient amounts. *Nutrients*. 10:1624.

Gregori D, Ballali S, Vogele C, Gafare CE, Stefanini G, Widhalm K. (2014). Evaluating food front-of-pack label- ling: a pan-European survey on consumers' attitudes toward food labelling. *Int J Food Sci Nutr*. 65:177–186.

Grunert KG, Fernández-Celemín L, Wills JM, Genannt Bonsmann SS, Nureeva L. (2010a). Use and understanding of nutrition information on food labels in six European countries. *Z Gesundh Wiss*. 18:261–277.

Grunert KG, Lahteenmaki L, Boztug Y, Martinsdottir E, Ueland Ø, Åstrom A, Lampila P. (2009). Perception of health claims among Nordic consumers. *J Consumer Policy*. 32:269–287.

Grunert KG, Wills JM, Fernández-Celemín L. (2010b). Nutrition knowledge, and use and understanding of nutrition information on food labels among consumers in the UK. *Appetite*. 55:177–189.

Grunert KG, Wills JM. (2007). A review of European research on consumer response to nutrition information on food labels. *J Public Health*. 15:385–399.

Hamlin R, McNeill L. (2016). Does the Australasian "Health Star Rating" front of pack nutritional label system work? *Nutrients*. 8:327.

Hawley KL, Roberto CA, Bragg MA, Liu PJ, Schwartz MB, Brownell KD. (2013). The science on front-of-package food labels. *Public Health Nutr.* 16(3):430–439.

Hersey JC, Wohlgenant KC, Arsenault JE, Kosa KM, Muth MK. (2013). Effects of front-of-package and shelf nutrition labeling systems on consumers. *Nutr Rev.* 71:1–14.

Hofstede G. 2011. Dimensionalizing cultures: the Hofstede model in context. Online Read Psychol Cult. 2.

Hofstede 2020. Country comparison. https://www.hofstede- insights.com/product/compare-countries/.

Ikonen I, Sotgiu F, Aydinli A, Verlegh PWJ. (2020). Consumer effects of front-of-package nutrition labeling: an interdisciplinary meta-analysis. *J Acad Mark Sci*. 48: 360–383.

Julia C, Ducrot P, Péneau S, Deschamps V, Méjean C, Fezeu L, Touvier M, Hercberg S, Kesse-Guyot E. (2015a). Discriminating nutritional quality of foods using the 5- Color nutrition label in the French food market: consistency with nutritional recommendations. *Nutr J*. 14:100.

Julia C, Hercberg S. (2017). Nutri-Score: Evidence of the effectiveness of the French front-of-pack nutrition label. *Ernahrungs Umschau*. 64:181–187.

Julia C, Kesse-Guyot E, Ducrot P, Peneau S, Touvier M, Méjean C, Hercberg S. (2015b). Performance of a five category front-of-pack labelling system - the 5-colour nutrition label – to differentiate nutritional quality of breakfast cereals in France. *BMC Public Health*. 15:179.

Kanter R, Vanderlee L, Vandevijvere S. (2018). Front-of-pack- age nutrition labelling policy: global progress and future directions. *Public Health Nutr*. 21:1399–1408.

la Cruz-Gongora V, Torres P, Contreras-Manzano A, de la Mota A, Mundo-Rosas V, Villalpando S, Rodriguez- Oliveros G. (2017). Understanding and acceptability by Hispanic consumers of four front-of-pack food labels. *Int J Behav Nutr Phys Act*. 14:28.

Mazzù MF, Romani S, Gambicorti A. (2020). Effects on consumers' subjective understanding of a new front-of-pack nutritional label: a study on Italian consumers. *Int J Food Sci Nutr*.

Méjean C, Deglaire A, Kesse-Guyot E, Hercberg S, Schlich P, Castetbon K. (2014). Association between intake of nutrients and food groups and liking for fat (The Nutrinet-Sante Study). *Appetite*. 78:147–155.

Méjean C, Macouillard P, Péneau S, Hercberg S, Castetbon K. (2013). Perception of front-of-pack labels according to social characteristics, nutritional knowledge and food purchasing habits. *Public Health Nutr*. 16:392–402.

Möser A, Hoefkens C, Van Camp J, Verbeke W. (2010). Simplified nutrient labelling: consumers' perceptions in Germany and Belgium. *J Verbr Lebensm*. 5:169–180.

Newman CL, Burton S, Andrews JC, Netemeyer RG, Kees J. (2018). Marketers' use of alternative front-of-package nutrition symbols: an examination of effects on product evaluations. *J Acad Mark Sci*. 46:453–476.

Pettigrew S, Jongenelis M, Miller C, Chapman K. (2017). A path analysis model of factors influencing children's requests for unhealthy foods. *Eating Behav*. 24:95–101.

Pineda E, Sanchez-Romero LM, Brown M, Jaccard A, Jewell J, Galea G, Webber L, Breda J. (2018). Forecasting future trends in obesity across Europe: the value of improving surveillance. *Obes Facts*. 11:360–371.

Radosavljevic Z, Foote N. (2020). Member states coalition presents latest challenge to colour-coded nutrition label. (accessed 2020 Oct 26). https://www.euractiv.com/section/agriculture-food/news/member-states-coalition- presents-latest-challenge-to-colour-coded-nutrition-label/

Reyes M, Luisa Garmendia M, Olivares S, Aqueveque C, Zacarias I, Corvalan C. (2019). Development of the Chilean front-of-package food warning label. *BMC Public Health*. 19:906.

Talati Z, Pettigrew S, Kelly B, Ball K, Dixon H, Shilton T. (2016). Consumers' responses to front-of-pack labels that vary by interpretive content. *Appetite*. 101:205–213.

Talati Z, Egnell M, Hercberg S, Julia C, Pettigrew S. (2019). Consumers' perceptions of five front-of-package nutrition labels: an experimental study across 12 countries. *Nutrients*. 11:1934.

Talati Z, Norman R, Pettigrew S, Neal B, Kelly B, Dixon H, Ball K, Miller C, Shilton T. (2017a). The impact of interpretive and reductive front-of-pack labels on food choice and willingness to pay. *Int J Behav Nutr Phys Act*. 14:171.

Talati Z, Pettigrew S, Neal B, Dixon H, Hughes C, Kelly B, Miller C. (2017b). Consumers' responses to health claims in the context of other on-pack nutrition information: a systematic review. *Nutr Rev.* 75(4):260–273.

Thaler RH, Sunstein CR. (2008). Nudge: improving decisions about health, wealth, and happiness. New York (NY): Penguin Books.

Thiene M, Scarpa R, Longo A, Hutchinson WG. (2018). Types of front of pack food labels: do obese consumers care? Evidence from Northern Ireland. *Food Policy*. 80: 84–102.

van der Bend DLM, Lissner L. (2019). Differences and similarities between front-of-pack nutrition labels in Europe: a comparison of functional and visual aspects. *Nutrients*. 11:626.

van Herpen E, Seiss E, van Trijp HC. (2012). The role of familiarity in front-of-pack label evaluation and use: a comparison between the United Kingdom and The Netherlands. *Food Qual Prefer*. 26(1):22–34.

van Kleef E, Dagevos H. (2015). The growing role of front-of- pack nutrition profile labeling: a consumer perspective on key issues and controversies. Crit Rev Food Sci Nutr. 55:291–303. Van Kleef E, Van Trijp H, Paeps F, Fernández-Celemín L. 2008. Consumer preferences for front-of-pack calories labelling. *Public Health Nutr.* 11:203–213.

Vargas-Meza J, Jauregui A, Pacheco-Miranda S, Contreras-Manzano A, Barquera S. (2019). Front-of-pack nutritional labels: understanding by low- and middle- income Mexican consumers. *PLoS One*. 14:e0225268.

WHO. 2020. Obesity and overweight. https://www.who.int/ news-room/fact-sheets/detail/obesity-and-overweight

4. Chapter 4 - The Role of Trust and Algorithms in Consumers' Front-of-Pack Labels Acceptance: A Cross-Country Investigation

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Abstract

This study aims to reveal the implications that trust, as a key driver of consumer behaviour, might have on consumer acceptance of front-of-pack labels (FOPLs) and policy effectiveness. By conducting three studies on 1956 European consumers with different levels of exposure to FOPLs, we offer additional theoretical and experimental support through a deep investigation of the central role of trust in consumers' decision-making toward healthier and more informed food choices. Study 1 utilized structural equation modelling (SEM) to assess whether trust is a relevant mediator of the relationship between attitude and behavioural intention, thus upgrading the Front-of-Pack-Acceptance-Model (FOPAM); Study 2 tested the model by comparing two labels at the extremes of the current European scheme (NutrInform Battery, Nutri-Score); Study 3 assessed the effect in cases where the connection between trust and algorithms is made transparent evaluated trust dimensions, focusing on the perception of an algorithm presence behind FOPLs information. Study 1 strengthen the FOPAM model with the mediating role of trust in FOPLs, demonstrating a positive effect of attitude on trust and, in turn, on behavioural intention, and resulting in a higher model fit with all the significant relationships; Study 2 revealed that the relative performance of the different labels on the FOPAM can be explained by the trust dimension; Study 3, investigating the dynamics of trust in the FOPAM, revealed that the Nutri-Score (NS) is less effective than the NutrInform Battery (NiB) on attitude, behavioural intention, and trust. This study increases the knowledge about the performance of different FOPLs on several dimensions of food decision-making, positions the upgraded FOPAM as a valid alternative to existing theoretical models to assess the relative performance of labels, also extending the literature in the context of algorithm-based FOPL, and could be used as a valid support to policy-makers and industry experts in their decision toward a unified label at European level.

[20] The study was developed by MFM, AB, SR, AA; data was analysed by MFM, SR, AB, AG; data interpretation was undertaken by MFM, AB, SR, AA; writing was carried out by MFM, AB, SR, AA.

Keywords: Trust, FOPAM, Algorithm, Nutri-Score, NutrInform Battery, Multiple Traffic Light, FOPL, Ease of Use, Usefulness, TAM

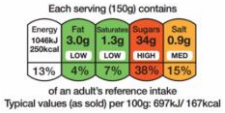
4.1. Introduction

In recent years, overweight and obesity have risen dramatically across all age groups worldwide. To date, the number of people suffering from obesity has nearly tripled since 1975, with over 340 million children and adolescents and over 1.9 billion adults reported as overweight or obese in 2016 (WHO, 2021). Furthermore, the projections are not encouraging, as nearly half of the world's population is likely to be obese by 2030 (Finkelstein *et al.*, 2012), with an increasingly larger proportion of younger people (WHO, 2021). This situation is partially resulting from an increased intake of high-sugar, high-fat, and high-salt, energy-dense foods. To support consumers in making more informed and healthier food choices and to control overweight and obesity, governments, authorities, socially responsible businesses, and organizations are asked to identify effective intervention to improve the information provided for their dietary decisions, leveraging and combining different approaches to encourage consumer responsibilisation (Parth *et al.*, 2020).

To this end, as packaging has emerged as an important element of brand management, in which many elements must be taken into account, such as the language adopted (Khan, 2019; Khan and Lee, 2020) and the appearance of standard versus local indications (Khan *et al.*, 2015; 2017), an increasing number of countries are adopting Front-of-Pack Labels (here in after as "FOPLs"). FOPLs are labels on the front of the packaging of pre-packaged foods (van der Bend and Lissner, 2019) that advise consumers on the composition of products, with the aim of promoting more informed and healthier habits. These labels have been suggested to draw consumers' attention more effectively than the ones traditionally placed on the back of products, especially due to the combination of their simplified format and prominent location on the front of the package (Elshiewy and Boztug, 2018; Becker *et al.*, 2015).

The absence of a standardized regulation has led over time to a wide variety of FOPLs, mainly grouped into two main categories: "Nutrient-Specific Labels" and "Summary Labels" (European Commission, 2020) (Table 1).

Table 1 - EU Taxonomy and example of Front-of-Pack-Labels

Taxonomies		Examples
Nutrient-Specific Labels: FOPLs that provide detailed information about certain nutrients (fat, saturates, sugars, salt, and energy value) with an objective description of the quantities contained in the food	• **Numerical Labels**: non-interpretative (non-evaluative) labels, providing numerical information on the content of four nutrients (fat, saturates, sugars, salt) and on the energy value, as well as on how much this represents as a percentage of the daily reference intake • **Colour-Coded Labels**: labels providing numerical information on the content of four nutrients (fat, saturates, sugars, salt) and on the energy value, as well as on how much this represents as a percentage of the daily reference intake. Colours are used to classify those nutrients as "low" (green), "medium" (amber) or "high" (red)	• **NutrInform Battery** (here in after as "NiB")  • **Multiple Traffic Light** (here in after as "MTL") 
Summary Labels: FOPLs that provide a synthetic assessment of the product's overall nutritional healthfulness that is sometime the result of an algorithmic computation	• **Endorsement Logos**: labels providing a synthetic appreciation of a product's overall nutritional value through a positive (endorsement) logo that is applied only to foods that comply with nutritional criteria • **Graded Indicators**: labels providing a synthetic appreciation of a product's overall nutritional value through a "graded indicator" that provides graded information on the nutritional quality of foods that is applied on all food products	• **Keyhole logo**  • **Nutri-Score** (here in after as "NS") 

In order to understand which FOPL would best support customers to make healthier food choices, previous literature has largely adopted the conceptual framework developed by Grunert and Wills (2007), focusing on consumers' objective and subjective understanding, and leading to controvertible evidence (Hersey *et al.*, 2013; Aschemann-Witzel *et al.*, 2013; Ducrot *et al.*, 2015b; De la Cruz-Gongora *et al.*, 2017; Egnell *et al.*, 2018a, 2018b; Talati *et al.*, 2019; Packer *et al.*, 2021; Mazzù *et al.*, 2020; Mazzù *et al.*, 2021a) of an absolute superiority of a specific FOPL capable of affecting consumer behaviour toward healthier lifestyles. Thus, new investigations are needed to include additional factors and develop alternative and complementary conceptual frameworks that help consumers' decision-making toward utilization and acceptance of FOPLs that support informed decisions toward healthier diets.

One dimension that is documented to strongly influence consumer decision-making is trust, which was mentioned by Hobbs and Goddard (2015) as a variable that should be investigated in order to understand its ability to influence consumer response to food labels, in a context where several health/functional elements are to be intended as credence attributes in food purchase. According to cue utilization theory (Cox, 1967), the label – and the information it provides – is an extrinsic cue on the product that consumers look for, especially when the product quality is uncertain. Therefore, label information acts as a source of trust and quality of food products (Ayyub *et al.*, 2018, 2021; Lassoued and Hobbs, 2015; Loureiro and

McCluskey, 2000). Consumers are more likely to buy or use a product or service they trust because trust reduces perceived risk among customers (Handi *et al.*, 2018; Harridge-March, 2006), which in turn increases their purchase intention (Bulut and Karabulut, 2018; Fang *et al.*, 2014; Limbu Yam *et al.*, 2012; Seo *et al.*, 2020). Conversely, trust, and consequently behavioural intention, may be negatively affected when concerns about perceived risk increase due to uncertainty (Pavlou, 2003), which is what consumers experience in circumstances where the amount of information generated by third parties is limited (Hong and Cha, 2013). For instance, in considering the increasing flow of information produced by algorithms to which consumers are subjected, several scholars (Granulo *et al.*, 2019; Logg *et al.*, 2019; Longoni *et al.*, 2019; Castelo *et al.*, 2019) focused on the implications of algorithm-based applications on trust. Following what has been suggested in the literature on trust, it is possible that, in the context of FOPLs, consumers may feel less trust in a label providing less information about the food content than in a richer and more detailed label. Furthermore, considering that some labels, such as the NS, are often constructed through algorithmic calculations, it might be of utmost importance to increase knowledge about the effects of algorithms on consumer behaviour regarding FOPLs. In addition, while several dimensions of trust have been explored, it remains unclear the underlying link that can support what public policies can be employed to influence trust (Hobbs and Goddard, 2015).

In this context, in a sequence of three studies from the consumer's perspective, we recognize and reveal the relevance of trust in predicting label acceptance and, by improving the front-of-pack acceptance model (FOPAM) (Mazzù *et al.*, 2021c), provide an alternative point of view to previous models. On a sample of 1956 Europeans, we explore the role of trust as a mediator of the relationship between attitude and behavioural intention, thus upgrading the FOPAM (Study 1), compare label effectiveness between two labels at the extremes of the current European FOPL scheme, the NS and the NiB, along the upgraded FOPAM framework (Study 2), and investigate the role of trust in the algorithm-based label as a mediator in the relationship between attitude and behavioural intention, while controlling the variable algorithm aversion (Study 3), and test the differences according to the two labels.

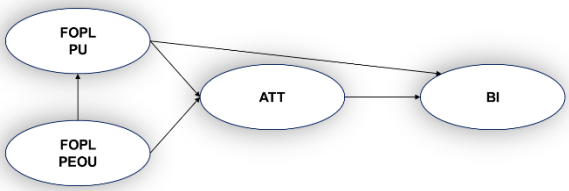
4.2. Theoretical background

Trust mediation in consumer acceptance of information

Previous research has led to conflicting results, with a lack of consistent evidence that a specific FOPL is more effective than others in supporting consumers toward more informed and healthier food choices along multiple variables; hence, the EU's goal of identifying a single common label to be used by a set of diverse European consumers remains far from being realized (Mazzù *et al.*, 2021b). This also generates a high level of debate in some countries (Carruba *et al.*, 2021), and stimulates researchers to identify additional criteria and theoretical frameworks that can support a proper FOPL selection by policy-makers.

Specifically, attention on consumers' comprehension has been broadened by a recent study that introduced the Front-of-Pack Acceptance Model (Figure 1) (Mazzù *et al.*, 2021c) with the aim of understanding whether consumers find labelling systems useful and easy to use when food shopping and whether they form their attitudes and intentions toward healthier products accordingly.

Figure 1 – Basic FOPAM



Drawing on the Technology Acceptance Model (Davis, 1989; Davis and Venkatesh, 2004), the FOPAM discusses the antecedents of behavioural intention, specifically, perceived usefulness and perceived ease of use, to shed light on what increases the likelihood of accepting the information conveyed by FOPLs. These constructs (Table 2) implied by the TAM, could also be investigated outside IT domains, such as in an FOPL-mediated context where the acceptance of information is required. They are also suitable for measuring the ability of a label to provide relevant (i.e., useful) and clear (i.e., ease of use) information to consumers to deepen the regard toward a label and the associated behavioural intention.

Accordingly, it has been demonstrated that perceived usefulness and perceived ease of use, when applied to an FOPL-mediated context, are significant predictors of attitude toward front-

of-pack labels, which in turn predicts behavioural intention toward using FOPL (Mazzù *et al.*, 2021c). Specifically, FOPLs influence in-store purchases as they inform consumers about the nutrients of the product and are comparable to the decision support system (DSS) that is frequently encountered and evaluated during food shopping (Caswell and Padberg, 1992; Hawley *et al.*, 2013).

Table 2 – TAM and FOPAM constructs on perceived ease of use, perceived usefulness, attitude

Variable	TAM	FOPAM
Perceived usefulness	"The degree to which an individual believes that using a particular system would improve his or her work performance" (Davis, 1989, 1993)	"The degree to which an individual believes that using a particular label would improve his/her healthier food choices"
Perceived ease of use	"The degree to which an individual believes that using a particular system would be devoid of physical and mental effort" (Davis, 1989, 1993)	"The degree to which an individual believes that the physical and mental effort required to use a particular label is limited"
Attitude	"The degree of evaluative affect that an individual associates with the use of the target system in his or her work performance" (Davis, 1993)	"The degree of evaluative affect that an individual associates with the use of the target label in his/her food choices"

Although it has been shown that perceived usefulness and perceived ease of use are relevant antecedents for the acceptance of FOPLs (Mazzù *et al.*, 2021c), it is also crucial to emphasize that consumers not only need to successfully interpret and understand information, but also trust it sufficiently to influence the decision to buy (Rupprecht *et al.*, 2020). Factors such as trust might increase the predictive power of TAM (Gefen, 2004), according to a meta-analysis of TAM conducted on 88 studies (King and He, 2006), and the same could be expected to happen with FOPAM.

In general, trust is an individual's attitude that has been defined by Hobbs and Goddard (2015) as "a heuristic that might be used in situations where lack of knowledge, experience or familiarity with firms, products or processes used to create products hampers decision making". Trust primarily concerns the willingness to accept something as true when vulnerability and uncertainty exist. Uncertainty is critical to trust because trust would be unnecessary if the trusting party has full control or total knowledge (Moorman *et al.*, 1993; Morgan and Hunt, 1994; Coleman, 1990; Deutsch, 1958). As Blomqvist (1997, p. 272) reasons, trust can only exist when information is imperfect because "under perfect information, there is no trust but merely rational calculation". In our study, a context of perfect information is missing because the full information is not available to consumers with both NS and NiB. In the case of NS, and Summary Labels in general, not all the nutritional information is present but a summary assessment of the product's overall nutritional healthfulness, elaborated by an algorithm, is given; in the case of NiB, and Nutrient-Specific Labels in general, consumers do not have a

summary of all the nutritional elements that provides a clear integrated indication to make a full comparison between, for example, different alternative dietary conditions. Thus, as FOPL information may still not be fully sufficient, trust appears to be critical in decision-making processes when FOPLs are assessed. This is true also when time constraints affect the consumer's opportunity to process information, make decisions, and perform certain behaviours, because consumers are unlikely to process details systematically if they are under pressure (Suri and Monroe, 2003). However, in such cases, trust in others acts as a heuristic and allows consumers to make decision based on the trustworthiness of information source, as suggested by Lewicki and Brinsfield (2011).

Trust has been mostly researched as a mediator variable (Chang and Chen, 2008) and has been considered a major influential factor in the decision-making process (Alhidari and Almeshal, 2017) in several contexts. Indeed, lack of trust could impact adoption of new technologies, generate political resistance to policies, and impede changes in behaviour that might otherwise be beneficial (Hobbs and Goddard, 2015). Conversely, with trust, consumers are more likely to engage in positive behaviours, such as purchase intention (Hong and Cha, 2013; Jiménez and San Martìn, 2014; Cuong, 2020; Mahmud *et al.*, 2020), repurchase intention (Trivedi and Yadav, 2019), and technology adoption (Van *et al.*, 2020; Kassim *et al.*, 2012; Siau and Shen, 2003). In addition, Dunning *et al.* (2012) show that trust is characterized by social and emotional aspects that cannot be underestimated and that it is necessary to address this aspect of trust in affecting various different decisions made at the level of the individual, also in relation to social behaviour (Kasperson *et al.*, 1992).

In the context of food purchasing (Del Giudice *et al.*, 2018; Glaeser *et al.*, 2000; Hobbs and Goddard, 2015), trust has been identified as an important predictor of acceptance of functional foods, foods affected by nanotechnology (Siegrist *et al.*, 2008, 2007) and unfamiliar vs. more familiar organic food labels (Janssen and Hamm, 2014). Also, Lobb *et al.* (2007), demonstrate that decisions to purchase food products are influenced by "significant interactions between trust, risk perceptions and attitudes". Then, Lang (2013) found that trust among organisations is quite variable when examining the stakeholders who the public trusts with respect to Genetically Modified foods.

Following this stream, some researchers have proposed trust as a mediator of the relationship between attitude and behavioural intention. For example, Nguyen *et al.* (2019) demonstrated

that attitude and website trust exert a direct and positive effect on the intention to purchase food online. Other authors have verified that trust is a mediating variable that is positively related to both consumer attitude formation and organic food purchase intention (de Magistris and Gracia, 2008; Wu and Chen, 2005; Yin *et al.*, 2010), implying that trust, when combined with a positive attitude, can drive positive behaviours such as purchase intent. Even in the context of labels, trust has been identified as an antecedent of purchase intention. According to Harris *et al.* (2011), consumers with a higher degree of trust in the label rely on a higher level of behavioural intention, whereas those who find labels less trustworthy show less willingness to buy. Talati *et al.* (2016) indicated that trust, along with ease of interpretation, was the main factor that impacted the willingness to incorporate FOPLs into the evaluation process. It is clear that in the food context, trust has a pivotal role as an important factor in individual food purchasing decisions of credence goods (Carfora *et al.*, 2019). Indeed, since there is information asymmetry about the characteristics of products (Cavallo *et al.*, 2018; Garcia and Teixeira, 2017; Janssen and Hamm, 2014; Jensen *et al.*, 2013; Nuttavuthisit and Thøgersen, 2017), an issue may arise when consumers think that certifications are not reliable (Carfora *et al.*, 2019). As to which elements can overcome this lack of trust, providing more information to the consumer can be positive (Atkinson and Rosenthal, 2014; Daugbjerg *et al.*, 2014).

However, although the studies previously mentioned suggest the active role of trust in the food context, to the best of our knowledge, the understanding of trust as a mediating variable of the relationship between attitude and behavioural intention in the context of FOPLs has been overlooked in the extant literature. These results indicate the possibility of demonstrating that, in the context of FOPL, the intention to use labels is positively influenced when consumers have greater confidence and trust in the labels. In fact, drawing on the definition of trust given by Moorman *et al.* (1993), both belief and behavioural intention must be present for trust to exist: trust is limited, if one only believes in the trustworthiness of the other, without being willing to rely on it, and viceversa. Hence, noting the role that the literature attributes to trust in information obtained from third parties, in both a technological and non-technological context, we propose the following:

H1. Trust mediates the relationship between attitude toward FOPL use and behavioural intention.

The comparative acceptance of Nutrient-Specific vs. Summary Labels

As discussed earlier, given the rise of different FOPL proposals outlined in the EU, several researchers have investigated the differences in terms of FOPL comprehension and liking based on the conceptual framework developed by Grunert and Wills (2007), producing conflicting results between objective understanding (Packer *et al.*, 2021; Andreeva *et al.*, 2020; Egnell *et al.*, 2018a, 2018b, 2019; Ducrot *et al.*, 2015b, 2015a; Aschemann-Witzel *et al.*, 2013; Hersey *et al.*, 2013) and subjective understanding (Mazzù *et al.*, 2020, 2021; De la Cruz-Gongora *et al.*, 2017; Hersey *et al.*, 2013). Table 3 provides a summary of previous studies.

Table 3 – Objective and Subjective Understanding: Summary of previous study

Variable	Evidence	Citation
Objective understanding	▪ Summary Labels are more effective.	▪ Ducrot *et al.*, 2015; ▪ Egnell *et al.*, 2018a, 2018b
	▪ Summary Labels are easier to decode and more suitable for capturing attention thanks to the use of colour.	▪ Ducrot *et al.*, 2015; ▪ Talati *et al.*, 2019; ▪ Hersey *et al.*, 2013; ▪ Aschemann-Witzel *et al.*, 2013
	▪ The NS (Summary Label) enhance participants' ability to identify the healthiness of foods and drinks more than the MTL (Nutrient-Specific Label), which is considered the most informative FOPL.	▪ Packer *et al.*, 2021
	▪ NS (Summary Label) achieves very positive results in terms of understanding and ability to allow respondents to rank food products in terms of nutritional quality.	▪ Ares *et al.*, 2018; ▪ Egnell *et al.*, 2018b; ▪ Finkelstein *et al.*, 2019; ▪ Talati *et al.*, 2019; ▪ Dréano-Trécant *et al.*, 2020
Subjective understanding	▪ Nutrient-Specific Labels are preferred because the completeness and specificity of the information allow consumers to better define nutritional values.	▪ Hersey *et al.*, 2013
	▪ The Summary Labels makes it easier to estimate the healthiness of a product, meeting the needs of consumers who have limited processing time and who are required to make a quick decision process	▪ Hersey *et al.*, 2013; ▪ De la Cruz-Gongora *et al.*, 2017
	▪ Consumers in multiple EU countries show preference for a richer and more informative label like the NiB (Nutrient-Specific Label), compared to the NS (Summary Label)	▪ Mazzù *et al.*, 2020, 2021a

The studies that compared the different FOPLs on objective understanding show, among other findings, a reduced degree of trust toward Summary Labels, mainly due to their simplicity and the smaller amount of information provided, when compared to Nutrient-Specific Labels (Talati *et al.*, 2019). However, knowledge on this topic is limited as there are no past studies in the literature that have evaluated trust by comparing nutrition labels. Therefore, we attempt to fill this gap by comparing, through the upgraded FOPAM, the NS in the category of "Summary Labels" and the NiB in the category of "Nutrient-Specific Labels". The former was developed

by French researchers and adopted by France and other European countries, while the latter was developed and proposed by Italy (Carruba *et al.*, 2021; Ares *et al.*, 2018; Egnell *et al.*, 2018b; Finkelstein *et al.*, 2019; Talati *et al.*, 2019; Dréano-Trécant *et al.*, 2020). These labels were selected as they stand at opposite ends of the current scheme outlined by the EU Commission (2020) and are prominent in the existing debate regarding the choice of an interpretive rather than informative supplementary nutrition labelling scheme (Carruba *et al.*, 2021).

Despite the wide adoption of NS by various countries and public institutions, results from Carruba *et al.* (2021) do not fully support the hypothesis that adopting this information system facilitates the conduction of a healthier lifestyle – maintaining a proper BMI or reducing the probability of developing overweight or obesity – but they recognize the NiB system as more flexible and potentially more informative. In this context of public health, the concept of trust could play a fundamental role in progressing consumption of health-oriented food products and the form of information on FOP which garners ease of access for the consumer and the usefulness of same. Hence, we expect that the NiB is likely to be perceived as more useful and easier by consumers, as Nutrient-Specific Labels convey more information and facilitate healthier choices for consumers (Talati *et al.*, 2019; Ducrot *et al.*, 2015; Aschemann-Witzel *et al.*, 2013; Hersey *et al.*, 2013), and to receive a higher attitude and trust rating, given the completeness and specificity of the information provided. Additionally, we hypothesize that the NS is more ease to be understood, as Summary Labels have been shown to facilitate the estimation of a product's healthiness (Hersey *et al.*, 2013), adapting to the needs of consumers who have limited processing time and are required to make quick decisions. Therefore, using the upgraded FOPAM model introduced in Study 1, we propose the following:

H2. Perceived usefulness of NiB is higher than that of the NS

H2a. Perceived ease of use of NS is higher than that of the NiB

H2b. Attitude toward the usage of NiB is higher than that of the NS

H2c. Trust toward NiB is higher than that of the NS

H2d. Behavioural intention toward NiB is higher than that of the NS

Trust toward algorithm-based labels

The main difference between Nutrient-Specific Labels and Summary Labels is the assessment of the contribution of a portion of food to nutrient intake. In the case of the former, numerical information is provided on the content of four nutrients (fat, saturated fat, sugar, salt) and the energy value, as well as what this represents as a percentage of the reference daily intake (EU, 2020, p. 3); in the case of the latter, however, an evaluative judgment is provided via a "graded indicator" on how the numerical values should be interpreted (EU, 2020, pp.3). According to the French Santé Publique (2021), the score for a food is determined according to a threefold process: (1) the assignment of favourable or unfavourable points to a nutrient, (2) a subtraction of the total number of favourable points from the unfavourable points, and (3) the definition of the given final score according to a predefined range. On the one hand, NS shows a graded indicator that uses both colours and letters to provide a synthetic assessment of the overall nutritional healthiness of the product. On the other hand, it exploits automated computing to form a second layer of judgment about food. Providing a graded indicator is attributed to a score, based on a predefined range, to a ratio based on the suggestions of experts and institutions. Conversely, in numerical Nutrient-Specific Labels, the information is focused on the nutrient ratio based on thresholds defined by experts and institutions. Information on how the NS algorithm is calculated are present in several forms, including digital platforms easily accessible by consumers.

Taking into account the differences described in the formulation of the information provided by the two labels, it is relevant to note that the effectiveness of Summary Labels might be undermined by the aversion of individuals to algorithms (Dietvorst *et al.*, 2015; Longoni *et al.*, 2019; Dawes, 1979; Einhorn, 1986; Highhouse, 2008; Grove and Meehl, 1996). In general terms, individuals are reluctant to allow a numerical formula to make decisions for them, even though algorithms often exceed human judgment in terms of accuracy (e.g., Dawes *et al.*, 1989). They resist adopting recommendations generated by non-humans, and they do not trust the algorithm's ability to make accurate inferences about their preferences (Dietvorst *et al.*, 2015; Longoni *et al.*, 2019). Indeed, although some studies propose an alternative model of algorithm appreciation (Logg *et al.*, 2019), arguing for the greater accuracy and precision of algorithmic judgments compared to human evaluations (Dawes *et al.*, 1989), most studies show that consumers respond less favourably to algorithms, particularly when they are used to making more intuitive decisions (Guszcza *et al.*, 2017; McAfee *et al.*, 2012) than when they need to

support the analytical aspects of decision-making (Jarrahi, 2018). Some of the reasons cited for causing aversion to algorithms are listed in Table 4.

Table 4 – Motives for algorithm aversion

Motives	Citation
Desire for perfect predictions	▪ Dawes, 1979; ▪ Einhorn, 1986; ▪ Highhouse, 2008
Inability of algorithms to learn	▪ Dawes, 1979
Ability of human predictors to improve through experience	▪ Highhouse, 2008
Notion that algorithms are dehumanizing	▪ Dawes, 1979; ▪ Grove and Meehl, 1996
Concerns about the ethics of relying on algorithms to make important decisions	▪ Dawes, 1979
Fact that algorithms cannot adequately consider individual goals	▪ Grove and Meehl, 1996
Inability of algorithms to incorporate qualitative data	▪ Grove and Meehl, 1996

Individuals have less trust in an algorithm than in an experienced human being (Castelo *et al.*, 2019), especially when the use of algorithms for each task seems to blur the boundary between humans and machines (the so-called "human distinctiveness threat"). Indeed, individuals rely more on a human advisor for more subjective decisions (Logg *et al.*, 2019), such as for medical care (Haslam 2006; Loughnan and Haslam 2007). One of the main reasons why domain subjectivity seems to undermine the increased reliance on algorithmic advice for objective estimates and predictions is closely related to the concept of uniqueness neglect, which identifies human concern about the inability of algorithms to explain a person's unique characteristics, as can humans (Longoni *et al.*, 2018).

The above evidence suggests that this concern could manifest itself also with food labels produced by algorithms, thus generating a lower level of trust when compared to human-based labels such as Nutrient-Specific Labels. Consumer trust toward labels is enhanced, according to Rupprecht *et al.* (2020), when information is provided by independent and neutral experts using scientific methods to test and analyse foods, rather than by other sources of food information. With regard to the operation of NS, marginal changes in some ingredients added in the production process have often caused a significant change in the output provided by the algorithm's calculation (Katsouri *et al.*, 2021), giving an example of its lower accuracy

compared to labels produced using expert judgment. In addition, Narciso and Fonte (2021) highlighted that NS could tend to discriminate products that, if eating in moderation, have been considered quite beneficial in a diet; simplification of nutritional content might then not help to properly inform consumers on what they should eat but rather it could create further confusion.

Therefore, on the basis of the above, we assume that:

H3. Attitude toward the usage of NiB is higher than that for NS, including in contexts where FOPL computational methods are transparent

H3a. Trust toward FOPL mediates the relationship between attitude toward using the FOPL and behavioural intention including in contexts where FOPL computational methods are transparent

H3b. Behavioural intention enhanced by NS is higher than that by the NiB including contexts where FOPL computational methods are transparent

H3c. Trust toward NiB is higher than that for NS including in contexts where the FOPL computational methods are transparent

This study contributes to the extant literature by analysing the effect of trust in consumers' decision-making toward healthier choices.

To this end, in a sequence of three sub-sequential and interlinked online experiments, on a cumulative number of 1956 primary grocery shoppers, we tested our hypothesis by (1) advancing the FOPAM (Mazzù *et al.*, 2021) assuming trust as a mediator of the relationship between attitude and behavioural intention; (2) observing potential mean differences between the NS and NiB according to the advanced FOPAM which involves trust as a mediator; and then (3) repeating the procedure of the two previous studies and strengthening the results in a context where the algorithm (and related computational methods) behind the labels were explicitly disclosed.

Indeed, in Studies 1 and 2, we evaluated the relationships among perceived usefulness, perceived ease of use, attitude, trust, and behavioural intention using a structural equation model, and then assessed the mean differences of the tested FOPL on each construct.

In Study 3, we deepened the results of Studies 1 and 2 by focusing only on the trust-mediated relationships between attitude and behavioural intention in the context of both disclosure of the computational methods behind FOPL and explanation of how the nutritional information is determined. Complementarily, we controlled for the algorithm aversion of individuals to prevent bias in the response.

4.3. Overview of studies

The development of three sequential studies allowed us to test our hypothesis according to (1) extant literature gaps, (2) the presence of FOPL in the country, and (3) the extent to which a FOPL has been tested. In Study 1, we assess whether trust is a relevant antecedent of behavioural intention, with the involvement of respondents from countries already adopting Nutrient-Specific Labels and a Summary Labels (UK and France). In Study 2, we compare a Nutrient-Specific Label and a Summary label, and test relevant differences according to the FOPAM, with the involvement of respondents from a country not adopting FOPL yet (Italy). Finally, in Study 3, we tested the liking for algorithm-based labels, again with the involvement of Italian respondents while preventing potential bias derived from previous exposure to the labels.

4.3.1. Study 1

Research and method

Participants and design. To ensure the recruitment of real consumers, for all three studies, we collected data derived from primary grocery shoppers on Prolific, a recently established international web panel provider that combines high recruitment standards and proper response rate, reliability, and high replicability of studies (Palan and Schitter, 2018). Primary grocery shoppers were included regardless of the traditional gender roles within the household, as highlighted by several authors (Bhatti and Srivastava, 2003; Richbell and Kite, 2007). According to the recent paradigm shift in purchases, the number of both male/female and non-binary shoppers is on the rise, irrespective of the traditional perspective (Otnes and McGrath, 2001; Richbell and Kite, 2007). Furthermore, the filter ensures higher confidence that the

interactions are associated with purchase-related tasks (Shim *et al.*, 1999). In Study 1, the sample consisted of 802 primary grocery shoppers from the UK and 703 from France. All participants accessed the study before an introductory screening of their knowledge of FOPLs. Those who never used FOPLS, both in real conditions and in the survey, were removed from the study, resulting in 800 valid cases for the UK and 670 for France.

Procedure. We evaluated the FOPAM model by analysing trust in the label as a mediator. The two groups of respondents were exposed to labels already present in their own market, namely the NS in France and MTL in the UK. We conducted our research focusing on the MTL and NS since these two labels reflect different poles of the recent classification outlined by the EU Commission (2020). Indeed, the NS is a summary label classified within the graded indicators, whereas MTL is a Nutrient-Specific label (EU Commission, 2020). The MTL system was introduced into the UK in 2004, while the NS was introduced in France in 2017. This allowed us to test our hypothesis in a sample already exposed to FOPL who were aware of the underlying functioning.

All participants were asked to assess the measures referring to perceived usefulness, perceived ease of use, attitude, and behavioural intention according to the labels of their own country. The FOPLs were described according to the definition provided by the French Health Ministry (2021) and the UK Health Minister (2019) for the MTL.

To ensure subject familiarity with the FOPL being rated, we asked whether participants had ever used the label. Those who had lower than daily/weekly usage of the FOPL in their purchases were exposed to an additional task concerning the creation of a personal basket while using the information reported on FOPL. Specifically, respondents were asked to complete an online experimental task that consisted of selecting up to 4 products with the FOPLs attached, on the basis of five product categories that would be served to them and their family for brunch. Operationally, respondents were dragging and dropping into a basket, with a maximum number of products allowed, their food selection. We select five product categories and in each of these we include two alternatives of the same product (conventional vs. light) based on the dietary composition, for a total of ten food products. We aim at presenting products with different composition and, as a consequence, a different representation in terms of FOPLs in order to allow consumers to better understand how each type works. The categories and products included (in brackets, the first mentioned is the conventional product and the second mentioned

is the light product) are the following: sauces (tomato with ricotta vs. tomato with basil), yogurt (fruit yogurt vs. zero-fat fruit yogurt), crackers (classic vs. corn), biscuits (classic vs. sugarless), and processed meat (salami vs. cooked ham). Those who accomplished the simulated food selection either not using FOPLs at all or using it less frequently were excluded from the study. Instead, more regular users of FOPLs were exposed to the assessment of the items and were asked to rate the extent to which they agreed with each statement using a 7-point Likert scale (from "Strongly Disagree" to "Strongly Agree").

Statistical analysis. The response set was used to assess the reliability and validity of the constructs and the overall fit of the structural model. We performed a decomposition test using the bootstrap method, which allows inference of indirect effects. We performed the analysis on 5,000 samples with a bias-corrected bootstrap with a confidence interval of 95%. Overall, we followed two steps to define a set of valid and reliable scales. At the beginning of the study, we tested the scale's reliability and validity, and then assessed the differences in means among the constructs. Specifically, in the first phase of Study 1, we measured the overall reliability using Cronbach's alpha (Cronbach, 1951). The coefficient alpha is used to test the internal consistency of a scale that describes the extent to which all the items in a scale measure the same concept or construct; hence, it is connected to the inter-relatedness of the items within the test. Consequently, a confirmatory factor analysis (CFA) was performed to further assess the discriminant and convergent validity of both constructs while controlling for their effects. Confirmatory factor analysis is used to test a hypothesis, inquiring whether an expected pattern corresponds to a predetermined simple structure (Johnston, 2014). Convergent validity refers to the extent to which the same trait is measured by different items, whereas discriminant validity is defined as the extent to which traits are distinct (Carmines and Zeller, 1979). We further tested the common method bias for the data. This helped to confirm whether the items were able to measure the considered variable and discriminate with others. Also, we tested the discriminant validity of constructs by using the Heterotrait-Monotrait (HTMT) ratio of correlations (Henseler *et al.*, 2015).

Finally, we tested the fit indexes of a structural equation model based on the research model (Mazzù *et al.*, 2021c; Davis, 1993) assuming relationships among perceived usefulness, perceived ease of use, attitude, and behavioural intention as latent variables. Then we evaluated the fit of the structural model. Structural equation modelling (SEM) allows the analysis of

multivariate data and results to be appropriate for theory testing. This embeds observed variables and latent constructs, allowing us to test the associated validity and hypothesized relationships among them (Bagozzi, 1980).

Results

The confirmatory factor analysis confirmed that the FOPAM fit for both countries was acceptable. The English sample displayed the following results: χ^2=285.021; p=0.000; GFI=0.951; CFI=0.979; NFI=0.973; SRMR=0.027; RMSEA=0.064 (Hu and Bentler, 1999); all indices suggested an acceptable fit to the data (Hu and Bentler, 1999); the French sample also resulted in a high model fit (χ^2=166.162; p=0.000; GFI=0.966; CFI=0.988; NFI=0.979; SRMR=0.0229; RMSEA=0.047 (Hu and Bentler, 1999). The Harman's test for common method bias suggested an overall variance below the cut-off of 505 for both UK (σ=48.87) and France (σ=41.27). For both samples, all items highlight a high level of reliability and validity with all factor loadings exceeding the suggested cut-off of 0.70 (Fornell and Larcker, 1981). The convergent validity suggests that all loadings measure the construct properly (λ>0.70 and SMC>0.50) while remaining distinctive among them as average variance extracted (AVE) is higher than squared multiple correlations (SMC) (Tables 5 and 6).

The HTMT reported values below the 0.90 cut-off for both samples (See Table 6) suggesting that the discriminant validity has been established and that constructs are able to discriminate the constructs under measurement (Henseler *et al.* 2015).

Regarding the structural model, specified on the basis of the proposed research model (Nguyen *et al.*, 2019), the model fit was acceptable: χ^2=299.186, p=0.000; GFI=0.949; CFI=0.978; NFI=0.972; SRMR=0.031; RMSEA=0.064 (Fornell and Larcker, 1981), indicating a high fit with the sample variance-covariance matrix. In addition, we found that all relationships were significant. In accordance with Nguyen *et al.* (2019), PEOU significantly predicted PU (β=0.583; p<0.001) and attitude toward using FOPL (β=0.266; p<0.001). Similarly, PU significantly affected attitude toward using FOPL (β=0.724; p<0.001) which in turn affects behavioural intention (β=0.300; p<0.001). Subsequently, we found a positive effect of attitude on trust (β=0.774; p<0.001) and trust in behavioural intention (β=0.138; p<0.01). Furthermore, we assessed whether trust was a significant mediator of attitude toward behavioural intention (β=0.106; p<0.025). This resulted in a direct effect greater than the indirect effect in the UK sample. Similarly, results from the French sample suggest a high fit of

the model with the sample data: χ^2=182.934; p=0.000; GFI=0.962; CFI=0.986; NFI=0.977; SRMR=0.0274; RMSEA=0.049. In addition, as in the previous model, all relationships were found to be significant. Perceived usefulness was positively affected by perceived ease of use (β=0.521; p<0.001). Attitude was significantly predicted by perceived ease of use (β=0.306; p<0.001) and perceived usefulness (β=0.658; p<0.001) and, in turn, attitude positively predicted behavioural intention (β=0.349; p<0.001). The effect of attitude on trust was found to be significant (β=0.684; p<0.001) which in turn positively affected behavioural intention (β=0.349; p<0.01). The mediation effects of attitude on the relationship between perceived usefulness and behavioural intention were positive (β=0.347; UL=0.360; LL=0.193; p<0.001). In this case, attitude partially mediates the effect of perceived usefulness on behavioural intention, considering the greater size of the direct effect when compared with the indirect effect. In comparison, considering the size of the direct effect of attitude on behavioural intention, trust partially mediates the effect of attitude toward behavioural intention (β=0.075; UL=0.117; LL=0.010; p<0.025).

Table 5 – Model assessment – Convergent validity

		UK (n=800)								France (n=673)							
Construct(s)	Item(s)	M	SD	CFA loading	SMC	t value	p	α	AVE	M	SD	CFA loading	SMC	t value	p	α	AVE
PU	Food Front-of-Pack label give (will give) me access to useful food purchase information	5.540	1.140	0.771	0.555	18.479	***	0.924	0.771	4.994	1.329	0.807	0.599	24.992	***	0.924	0.756
	Food Front-of-Pack label are (will be) bery beneficial to me	5.330	1.307	0.921	0.773	14.020	***			4.782	1.369	0.893	0.714	29.382	***		
	Using Food Front-of-Pack label improves my food purchase	5.090	1.390	0.922	0.791	13.891	***			4.890	1.395	0.911	0.768	30.408	***		
	Using Food Front-of-Pack label gives me greater control over my food purchase	5.260	1.374	0.862	0.704	16.949	***			4.848	1.430	0.863	0.691	27.792	***		
PEOU	My interaction with the Food Front-of-Pack label is easy for me to understand	5.970	0.980	0.911	0.769	13.477	***	0.936	0.832	5.878	1.084	0.796	0.563	24.477	***	0.888	0.734
	Overall, I find the Food Front-of-Pack la bel easy to use	6.020	0.987	0.947	0.797	9.253	***			5.997	1.056	0.918	0.704	29.776	***		
	It is easy to learn how to use Food Front-of-Pack label for food purchase	6.050	0.955	0.876	0,711	15.850	***			5.990	1.058	0.850	0.628	26.441	***		
ATT	I am positive about the Front-of-Pack label for food purchase	5.620	1.183	0.914	0.726	14.421	***	0.933	0.828	5.596	1.320	0.906	0.737	30.134	***	0.929	0.816
	The use of the Front-of-Pack label for food purchase is a good idea	5.930	1.039	0.898	0.762	15.486	***			5.731	1.217	0.918	0.773	30.795	***		
	It makes sense to use the Front-of-Pack label for food purchase	5.820	1.090	0.917	0.770	14.204	***			5.545	1.292	0.884	0.701	28.916	***		
BI	I will use the Front-of-Pack label for food purchase in the future	5.580	1.315	0.942	0.480	5.850	***	0.810	0.681	5.209	1.453	0.942	0.480	0.532	***	0.842	0.746
	I will recommend using Front-of-Pack label for food purchase to my friends	4.790	1.597	0.736	0.480	17.952	***			4.579	1.584	0.736	0.480	0.532	***		
TTL	This Front-of- Pack label inspires confidence	5.240	1.159	0.875	0.344	22.223	***	0.739	0.586	5.231	1.135	0.863	0.399	23.086	***	0.774	0.640
	Food products with Front-of-Pack labels are reliable and trustworthy	5.300	1.114	0.864	0.344	22.907	***			4.855	1.167	0.732	0.399	19.372	***		

Table 6 – Model assessment – Heterotrait-Monotrait ratio of correlations for discriminant validity

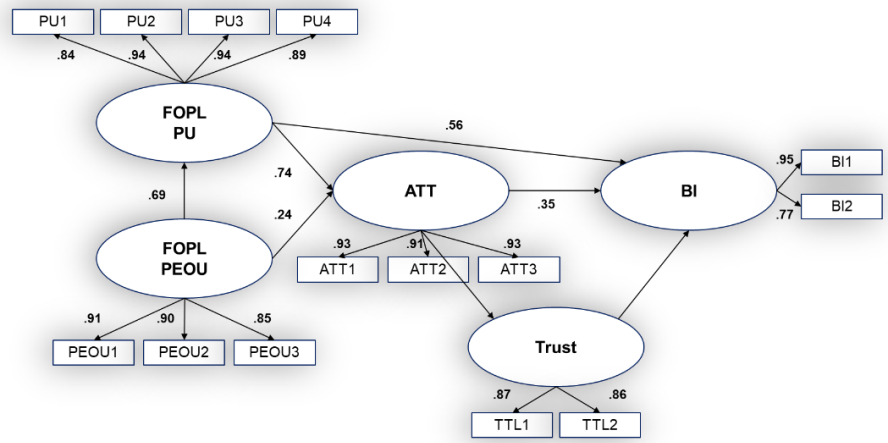
UK (n=800)					
	PEOU	PU	ATT	BI	Trust
PEOU					
PU	0,527				
ATT	0,615	0,752			
BI	0,444	0,689	0,689		
Trust	0,45	0,454	0,524	0,438	

France (n=673)					
	PEOU	PU	ATT	BI	Trust
PEOU					
PU	0,603				
ATT	0,639	0,803			
BI	0,547	0,760	0,809		
Trust	0,532	0,655	0,726	0,730	

Discussion

The results of Study 1 provide support for our basic premise that trust mediates the relationship between attitude and behavioural intention, allowing us to highlight its relevant contribution in food consumer decision-making supported by FOPLs. Since relationships among variables are confirmed, and trust is observed to be a mediator in the relationship between attitude and behavioural intention, H1 is supported. Analysis of the above results verified that trust is a determinant of behavioural intention, particularly reinforced by attitude, thus enabling the introduction of the trust-mediated FOPAM model, as displayed in Figure 2, based on the results derived from two countries already exposed to different FOPLs and two samples of primary grocery shoppers.

Figure 2 – Trust-mediated FOPAM model



4.3.2. Study 2

Research and method

Participants and design. In Study 2, both labels were tested on 202 Italian respondents, since Italy is a country where any FOPL system has been previously adopted.

Procedure. In Study 2, we assessed the mean differences according to the constructs tested and validated in Study 1. Indeed, to the best of our knowledge, this is the first study to measure the mean differences of FOPLs' perceived usefulness, perceived ease of use, attitude, and behavioural intention. As in the previous study, the items were evaluated by respondents after being exposed to the NiB and NS with cues from descriptions derived by the French Health Ministry (2021) and the Italian Economic Development Ministry (2021). Participants were then asked to rate the extent to which they agreed with each statement using a 7-point Likert scale (from "*Strongly Disagree*" to "*Strongly Agree*").

Statistical analysis. In Study 2, we assessed the reliability of items and then ran an independent t-test to explore potential mean differences according to the items evaluated.

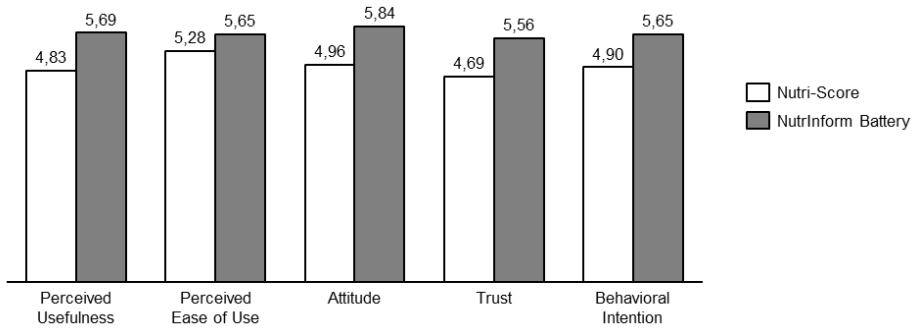
Results

We validated our results using an independent two-sample t-test for each dependent variable, namely perceived usefulness, perceived ease of use, attitude toward using the FOPL, behavioural intention, and trust toward the label. The following results were organized according to the variables analysed. In addition, all the measures collected in the study were above the suggested cut-off of 0.7 of Cronbach's alpha (Cronbach and Gleser, 1959). Perceived usefulness was 0.952, perceived ease of use 0.899, attitude scale 0.969, behavioural intention 0.936 and trust 0.949.

Assuming perceived usefulness as the dependent variable, the results showed a positive mean difference (MD=−0.859; $p<0.05$) between the NiB (M_{NiB}=5.69; SD=1.20) and NS (M_{NS}=4.83; SD=1.70). This indicates that respondents perceive the NiB as more beneficial and useful for providing information about the food and improving their control over the purchase. Regarding perceived ease of use, the results highlight a significant mean difference (MD=−0.39; $p<0.05$) between the NiB (M_{NiB}=5.65; SD=1.17) and NS (M_{NS}=5.28; SD=1.41). The Nutrient-Specific label is perceived as easier to understand and use than the NS. Similar results were also confirmed for attitude toward the label. However, a significant mean difference (MD=−0.87; $p<0.05$) between the NiB (M_{NiB}=5.84; SD=1.32) and NS (M_{NS}=4.96; SD=1.85) was assessed. Thus, respondents are more likely to develop positive attitudes toward the NiB rather than the NS. In addition, significant results have been highlighted, assuming trust toward the label as a dependent variable. Indeed, the NiB (M_{NiB}=5.56; SD=1.43) significantly differs from NS (M_{NS} =4.69; SD=1.69) (MD=-0.87; $p<0.05$). Hence, respondents

found the Italian label to be more reliable and trustworthy than the Summary Label. Regarding behavioural intention, respondents are more inclined to use and recommend the NiB than the NS. In fact, the results highlight a significant mean difference between the two labels. The NiB reported a mean of M_{NiB}=5.65; SD=1.41 whereas the NS of M_{NS}=4.90; SD=1.89, resulting in a mean difference of MD=−0.74 ($p<0.05$). All results are shown in Figure 3.

Figure 3 – Mean differences between NS and NiB



Discussion

The results of Study 2 demonstrate that the relative performance of different labels on FOPAM can be explained by the dimension of trust. Study 2 highlighted the better effectiveness of the NiB compared to the NS with regard to perceived usefulness, perceived ease of use, attitude, trust, and behavioural intention, supporting H2, H2b, H2c, and H2d, respectively while leading us to reject H2a. The above results indicate that respondents perceive that the NiB is better than NS, thus contributing to knowledge on the debate about the superiority of FOPLs. Specifically, the NiB is perceived as more beneficial and useful for providing information about food, improving consumers' control over the purchase, and easier to understand and use than the NS. Moreover, consumers are more likely to develop positive attitudes toward the NiB, which is considered more reliable and trustworthy than the Summary Label, and are more inclined to use and recommend the NiB than the NS.

4.3.3. Study 3

Research and method

Participants and design. Study 3 involved once again respondents from Italy, as they are not aware of the computational elements behind the different FOPLs, since no FOPL system has yet been adopted in the market. Participants amounted to 199 for this round.

Procedure. Since the definition of the algorithm is now under investigation and is mathematically and philosophically challenging (Moschovakis, 2001), prior to the study we performed a manipulation check on 60 Italian primary grocery shoppers. Respondents were asked to judge how the nutritional information presented on two different FOPLs and their consequent output applied to the packaging (i.e., NS and NiB), were formed. Specifically, using a seven-point Likert scale, consumers evaluated whether they perceived the nutritional information provided by FOPLs deriving from an algorithm, a nutritional expert, a consumers' associations, firms or an institution. This step allowed us to define whether consumers naturally recognize the different degrees of algorithm presence in each FOPL design.

Subsequently, we tested the mediation effect of trust between attitude and behavioural intention, cueing the description of both labels with computational details derived from the official methodologies developed by the Italian Economic Development Ministry (2021) for NiB, and the French Health Ministry (2021) for NS. We collected a total of 197 Italian primary grocery through an online survey which provided the computational information behind the FOPL. The analysis was organized in two steps: first we developed a mediation analysis between attitude, trust, and behaviour; and then the response set was used to test the mean differences among the experimental conditions. The items involved in the study were the same as those used to collect responses in Studies 1 and 2 (see Table 4.a). However, the stimuli adopted varied according to the aforementioned design. Hence, the respondents answered the same questions in Studies 1 and 2 after being randomly exposed to the description of the computational methods behind the FOPL. Eleven outliers were excluded from the study.

Statistical analysis. In Study 3, assuming behavioural intention as DV, attitude as IV, and trust as a mediator while controlling for algorithm aversion, we ran a mediation analysis using Model 4 in PROCESS (Hayes, 2017).

Results

Manipulation Check. We first checked how many respondents indicated that one of the two labels appeared more algorithm-based rather than outlined by nutrition experts, consumers' associations, institutions, or firms. The results revealed that respondents perceived the French NS as more algorithm-based (M_{NS}=4.39; SD=1.606) than the NiB (M_{NiB}=4.04; SD=1.710; t(1.57=815; $p<0.05$). Importantly, these results demonstrate that NS directly leads to an increase

in the perception of algorithm-based graded indicators, whereas the NiB, composed of a sequence of percentages, reflects an expert computation behind the values.

These results allowed us to assess whether consumers perceive different underlying computational sources connected to the labels. Also, the results suggest that consumers properly discriminate among the different computational method of the information reported on the labels and recognize the different nature of the FOPL (i.e., algorithmic-based, expert-based or institutional-based FOPL). Hence, we further assessed the relevance of these differences in the main study checking the effects of the disclosure of the computational methods. To control these effects, we also measured the algorithm aversion and used it as a control variable.

Mediation analysis. Then, to test H3, we used Model 4 of PROCESS, controlling for algorithm aversion which was evaluated using the PANAS scale (Watson *et al.*, 1988). We first regressed trust toward the algorithmic label on the attitude toward using FOPL, and then regressed behavioural intention on trust and attitude toward its use. The results showed that an increase in attitude toward using the FOPL led to a higher trust of the label ($b=0.73$; $t(189)=16.37$; $p<0.001$); the trust, in turn, positively affected consumers' behavioural intention ($b=0.36$; $t(189)=6.26$; $p<0.001$). However, because the algorithm aversion does not vary significantly across the sample, we found it to be insignificant ($b=0.25$; $t(189)=0.92$; $p=0.35$). When considering attitude toward using FOPL in the regression model with behavioural intention (BI) as the dependent variable, the variable shows a positive significant effect on BI ($b=0.53$; $t(189)=9.691$; $p<0.001$). More importantly, the indirect effect of trust variable on BI was positive and significant ($b=0.2607$; 95% CI:0.1659 – 0.3675), thus confirming that trust partially mediates the effect of attitude toward using the label on behavioural intention (H3a).

FOPL superiority on constructs. Next, to assess whether the FOPLs cued with computational details significantly varied the perception of the two FOPLs, we ran a sequence of independent two-sample t-tests. With regard to the comparison between NS and NiB cued with computational information, the Nutrient-Specific label showed higher means in terms of attitude ($M_{NS}=5.30$; $SD=1.56$ vs. $M_{NiB}=6.03$; $SD=0.84$; $t(1.189)=-3.778$; $p<0.001$) and trust ($M_{NS}=4.94$; $SD=1.47$ vs. $M_{NiB}=5.58$; $SD=0.90$; $t(1.189)=-3.410$; $p<0.001$). Similarly, BI varied significantly between the two labels ($M_{NS}=5.30$; $SD=1.47$ vs. $M_{NiB}=5.89$; $SD=0.94$; $t(1.189)=-3.134$; $p<0.001$). Hence, the NiB showed significant and positive mean differences

in terms of trust, attitude, and behavioural intention when the two labels were cued with details referring to the computational information. Thus, H3, H3b, and H3c are supported.

Discussion

The results of Study 3 provide additional evidence for the proposition that trust plays a mediating role between attitude and behavioural intention by further assessing its effect in cases where the connection between trust and algorithms is made transparent. One of the main insights of this study is that consumers are able to recognize the fact that an FOPL is derived from complex computational models and differentiates against others which are not. Indeed, thanks to a deepening of the construct of trust, it is possible to understand the extent to which even an indirect presence of algorithmic elements can result in changes in consumer decision-making. In fact, trust in FOPL cued with algorithms could be a key element in acknowledging whether the acceptance of specific labels, based on computational methods, can be compromised by algorithm aversion. In addition, Study 3 revealed a significantly different perception of the two labels among respondents in terms of the perception of algorithm presence. Furthermore, on the one hand, NS directly leads to an increase in the perception of the algorithm behind the graded indicators; while on the other, the NiB, composed of a sequence of percentages, reflects an expert computation behind the values.

The results also showed that an increase in attitude toward using the FOPL led respondents to feel greater trust in the label, positively affecting their behavioural intention. Thus, it was confirmed that trust partially mediates the relationship between attitude and BI, supporting H3. In addition, examining the results for the individual variables shows evidence that the NS was less effective than the NiB on attitude, behavioural intention, and trust, supporting H3, H3b, and H3c, respectively. Moreover, the results indicated that respondents do not vary their attitude toward the label, trust, and behavioural intention if the FOPLs are combined with computational details. Indeed, consumers recognize the nature of labels, regardless of the information provided. However, comparing the NS and NiB under the condition of computational information disclosure and not, the latter relies on a higher degree of trust and attitude in both scenarios. Hence, the NiB showed significant and positive mean differences in terms of trust, attitude, and behavioural intention when the two labels were cued with details referring to computational information.

4.4. Discussion

Theoretical and managerial implications

While the importance of FOPLs has been acknowledged in prior research (Hersey *et al.*, 2013; Aschemann-Witzel *et al.*, 2013; Ducrot *et al.*, 2015b; De la Cruz-Gongora *et al.*, 2017; Egnell *et al.*, 2018a, 2018b; Talati *et al.*, 2019; Packer *et al.*, 2021; Mazzù *et al.*, 2020; Mazzù *et al.*, 2021a), a consensus has not been achieved on which label would be the best to support customers towards more informed and healthier food choices. Drawing on the fundamental variables of consumer objective and subjective understanding in the framework proposed by Grunert and Wills (2007), researchers found different evidences (Hersey *et al.*, 2013; Aschemann-Witzel *et al.*, 2013; Ducrot *et al.*, 2015b; 2017; Egnell *et al.*, 2018a, 2018b; Talati *et al.*, 2019; Mazzù *et al.*,2020; Mazzù *et al.*, 2021a) resulting, depending on the situation, in a higher effectiveness of Summary Labels (e.g., NS) or of Nutrient-Specific Labels (e.g., NiB).

The need to move from the focus of research from understanding toward a new framework has been advanced by the new FOPAM model (Mazzù *et al.*, 2021b) which, however, overlooked the importance of trust, as a fundamental variable in food decision-making, and as a relevant antecedents of the acceptance (Handi *et al.*, 2018; Harridge-March, 2006). Indeed, in Study 1 we clarified the centrality of trust toward FOPL as a determinant of behavioural intention towards labels and a mediator of the relationship with attitude, shedding a light on the fact that behavioural intention connections were most mediated by trust. This, in turn, motivates consumers to adopt the FOPL. These findings suggest the importance for institutions and regulators of being aware of those labels which are more likely to inspire trust among consumers.

According to bounded rationality, consumers tend to take suboptimal decisions due to cognitive limitations, imperfect information and time constraints. When buying food products, they are exposed to a lack of information given by the credence nature of some food products and the related difficulty to assess their attributes even after consuming them. In this vein, FOPL might support the change of the perception of nutrients from credence to search food attributes and are adopted as an extrinsic cue which appear to be useful in situations when credence characteristics predominate the decision-making process (Fotopoulos and Krystallis, 2003). However, in this credence-to-search transformation process, there are at least two implicit mediators intervening in the decoding process that need to be trusted: the computational method

behind the transformation process and information (i.e., the algorithm), and the information source (i.e., the label). Further, Summary Labels do not present a detailed explanation of the attributes whereas Nutrient-Specific ones do not summarize the nutrients in a sole indicator that could be easily benchmarked. In this vein, the paper shed light on the fundamental role of trust as a mediator by confirming how this variable can change the output of the behavioral intention and, subsequently, confirms how consumers attach variable levels of trust towards different computational methods and labels. Furthermore, it can even act as a heuristic to take decisions. To the extent of our knowledge, it is the first contribution highlighting the role of trust in FOPL-mediated context and comparing its outcomes in relation to Nutrient-Specific and Summary Labels.

In contrast, it may be argued, that both components, the computational methods and information source, can contribute to the generation of an imperfect information. In fact, consumers may ignore the rationale of the calculations behind the FOPL and how the label is built. This leads to a relevant implication for policy makers and food brands, that should intervene to educate consumers towards the usage of this labels that will become mandatory in all European countries in the upcoming years. By promoting these labels and their rationale, they will increase their related expertise and, in turn, drastically decrease the credence component of foods and allow them to take a more informed decision.

The upgraded FOPAM, validated cross-country in Study 1, could then be used as a valid alternative to existing models based on understanding to assess the superiority of different FOPLs. The structural elements of the model – ease of use and usefulness –, combined with trust as a key mediator, take into account and balance the strengths of the different categories (e.g., Summary vs. Nutrient-Specific) of FOPLs, toward the formation of behavioural intention.

The FOPAM offers a comprehensive reading of the antecedents of the FOPL acceptance. In fact, if compared to other models discussed in the literature (i.e., Grunert and Wills, 2007), it integrates a set of variables that can potentially favour the outcomes of both Summary Labels and Nutrient-Specific Labels. According to previous studies, the NS should be easier to use while the NiB more informative and useful. However, this evidence have been tested only focusing on specific parts of theoretical models. If we observe the model of Grunert and Wills (2007), it integrates objective and subjective understanding in the same model, but the majority

of evidence arise only by focusing either on the subjective or objective part, leading to opposite results.

In contrast with previous studies, this paper theoretically contributes to the literature by offering a comprehensive and balanced model able to take into account the diversity of all FOPL and explain their effectiveness while avoiding to be construct-specific.

Also, considering the implied differences in the European territories in terms of cultures and the aforementioned absence of homogenous results in the literature, the EU could opt for a non-univocal choice allowing countries to implement the preferred options. The most recent goal of EU policy-makers, is to find an harmonized and universal labelling system to adapt in all European countries. However, there are two current risks that EU should contrast. The first risk is to outline a labelling scheme which is not fully supported by converging evidence. The second one refers to the risk to implement a labelling scheme grounded on the evidence created on recurrent models and overlook the fragmentation of other valid positions in the literature that together contribute to depict an environment in which the different and still valid results reflect the diversity of alternatives that are equally effective. The right choice of FOPL would benefit the food industry but, there are still additional usage gaps that must be fulfilled to define the best option. This study represents an initial contribution to this field.

The Study 2 than showed that the NiB would obtain superior responses to NS across all dimensions of FOPAM. Consumers tend to perceive NiB as more trustworthy and are able to guide consumer choice in an informed way. In addition, in facilitating consumers' understanding of information, the NiB experiences limited impact from sociocultural differences compared to the NS (Mazzù *et al.*, 2021a), rebalancing the claim that age, socioeconomic status, and education influence consumer choice, regardless of the amount and type of information contained in FOPLs (Narciso and Fonte, 2020; Grunert and Aachmann, 2016). In conditions of imperfect information, consumers might prefer labels able to summarize the information. However, this study further contributes to literature highlighting that in context of imperfect information, consumers tend to prefer Nutrient-Specific Labels as more informative, detailed and able to clarify the credence components of the product. It suggests that policy makers should find the right balance between informative labels and summary ones. Further research might also explore whether bundling of FOPL could generate healthier and more informed food choices; a potential solution in line with the “Presidency Conclusions on

front-of-pack nutrition labeling, nutrient profiles and origin labeling" document which allows member states to use their respective FOPL while bundling their proposal alongside the upcoming harmonized EU FOPL scheme (EU Commission, 2020b).

While prior research has identified the variation of the understanding of the labels, the liking or the units consumed by users, our findings further advance extant theory by observing the differences in the variables involved in the FOPAM and showcasing the higher level of trust attached to the NiB. In general, consumers purchase intention increases with trust because they perceive less risk and uncertainty (Handi *et al.*, 2018; Harridge-March, 2006) and thus are more likely to buy or use a product or service (Bulut and Karabulut, 2018; Fang *et al.*, 2014; Limbu Yam *et al.*, 2012; Seo *et al.*, 2020); conversely, consumers experience uncertainty when fewer information is available (Hong and Cha, 2013). Therefore, in an FOPL context, consumers are least likely to trust a poorly-detailed label on food content compared to a richer, more informative label.

In addition, considering that some labels, such as NS, are claimed to be the result of algorithmic calculations, this study shows statistically significant differences in the effects of algorithms on consumer behaviour and investigates whether the mediating role of trust in the label is also effective in these contexts. In this context, Study 3 further extends the literature on food decision-making by clarifying the acceptance in settings where the FOPLs underlying computational model are made transparent to consumers. As shown in Study 3, adding details relating to the computational method that each type of label adopts did not change the results for the NiB, which always remained higher than for the NS, which instead recorded a greater negative perception. FOPL cued with algorithms appears to be less trustworthy and consumers' evaluation is compromised by algorithm aversion (Dietvorst *et al.*, 2015; Longoni *et al.*, 2019; Dawes, 1979; Einhorn, 1986; Highhouse, 2008; Grove and Meehl, 1996). The study 3 further aspires to provide additional support to policymakers in understanding the complex process of label acceptance and consequently develop guidelines that could promote better dietary habits among consumers. It also contributes to the advice-taking literature through an empirical examination of the resistances deriving from the adoption of non-human recommendations (Dietvorst *et al.*, 2015; Longoni *et al.*, 2019) highlighting that consumers respond less favourably to algorithms when they need to support the analytical aspects of decision-making (Jarrahi, 2018). An efficient education strategy activated by policy-makers and food brands,

could shed light on the computational methods of the labels, highlight their benefits in orientating consumers toward healthier choices and automatise the informative process.

The FOPAM represents a research model that is complementary to other approaches adopted in the literature, such as that developed by Grunert and Wills (2007), expanding the set of available theoretical support for labelling and food consumers' decision-making. The evidence from this study is relevant to institutions, who could thus be encouraged to base their labelling policies on the fact that consumers may be less inclined to accept labels they consider less trustworthy. Also, these findings can lead consumers on the path to food well-being that is a collaborative venture between consumers and food providers (Bogomolova *et al.*, 2020). In this vein, marketers and regulators can also interact with customers to co-create products that meet their needs (Ashman *et al.*, 2020), or stimulating insights on consumers' interpretation of the food label (Machín *et al.*, 2021). In a context where health "is used by marketers to idealize, embellish, and highlight the positive aspects of the food industry over the more controversial ones" and to connect with other concerns such as sustainability and nutrition (Silchenko and Askegaard, 2020), FOPL could support proper informed choice about the real composition of the product and move consumers toward healthier food choices.

Finally, the upgraded FOPAM offers an alternative theoretical model to move forward in the European debate for assessing the relative effectiveness of different FOPLs and for preventing the possible introduction of less reliable and effective labels, from the point of view of customer acceptance, and could help overcome the concern highlighted by previous models by acting as a potential support to institutions that are considering which common FOPL to adopt.

Present limitations and opportunity for future research

Our study has some limitations. The sample consisted of Italian, French, and English respondents and two FOPLs. Future research should therefore try to target individuals from different countries to ascertain whether the results are broadly generalizable, and measure the potential moderating effect of FOPL knowledge among different customer groups. Furthermore, although our research has made trust relevant, the model could be further integrated by considering other variables, such as actual use and perceptual use, user experience level or type of users, and type of use, which were employed as moderators in the past applications of the TAM (King and He, 2006; Venkatesh, 2000).

It would also be of value to expand the current study by including in the perspective, also in the light of the From-Farm-to-Fork strategy, the inter-play and the effects of combining food and eco-sustainable labels on consumers' food decision making.

In addition, our study posits that consumers do or do not trust information about FOPL. However, the presence of trust could be a consequence of their perception that the FOPL information is telling the truth. In fact, consumers should not trust the brand or product if they believe the FOPL information is false or not entirely honest. As a result, future research could also study respondents' perceptions of whether what they read on the label is true or not in order to understand if this has implications for trust.

Finally, we mentioned the opportunity for marketers to engage with customers to collaboratively create products that meet their needs, stimulating insights into consumer interpretation of the food label (Machín *et al.*, 2021). This process can be extended, becoming appealing for future research, to include a design thinking approach that can enable the development of "generative engagement" (Garud *et al.*, 2008) to usher in change toward sustainable practices (Parth *et al.*, 2021).

4.5. Conclusion

In conclusion, this research contributes to the European debate with the aim of providing an alternative viewpoint to that offered by Grunert and Wills (2007) to confront food decision-making processes, that of the consumer. In our study, we demonstrated that a strengthened theoretical contribution in FOPAM is of significant practical contribution as support to decision-makers, avoiding the problem of non-converging evidences, shown by previous models, in assessing the effectiveness of different FOPLs. The upgraded FOPAM could help overcoming this, as a potential support to Institutions that are currently evaluating which common FOPL should be adopted. Through three studies, we have revealed the implications of trust, as a key factor of consumer behaviour, on consumer acceptance of FOPLs, providing theoretical and practical support to policymakers through an upgraded version of the recent FOPAM used to explore the mediating role of trust. In fact, trust has not only proved to be a determining factor in the behavioural intention of consumers toward food labels but has also made it possible to build a model capable of measuring the different performances of two divergent labels – the NiB and the NS – leading to clear and incontrovertible results on the

superiority of the NiB across all dimensions of the FOPAM (ease of use, utility, attitude, trust, and behavioural intention).

The results of these studies provide new findings on the effectiveness of the FOPAM and on the role of trust in influencing consumer response to FOPL. The issues addressed are all of direct public policy relevance, since the adoption of Nutrient-Specific Labels could be beneficial to consumers. The NiB system allows the consumer to make informed choices on whether to eat that specific product based on its personal decision, knowing that it should not go over the suggested daily intake to maintain a healthy diet (Narciso and Fonte, 2021). Non-directive labels require more cognitive effort from the consumer, but in the long run, this could favor an increase in nutrition knowledge and more balanced dietary patterns (Muzzioli, *et al.*, 2022). If trust plays a role in influencing consumer acceptance of these labels, then policymakers are encouraged to promote nutrition education among consumers through the diffusion of specific food labels, and clarify more the algorithmic essence of some of them.

References

Alhidari, A.M. and Almeshal, S. A. (2017), “Determinants of purchase intention in Saudi Arabia: A moderating role of gender”, *Journal of Economics, Management and Trade*, Vol. 17 No. 2, pp.1-10.

Andreeva, V.A., Egnell, M., Handjieva-Darlenska, T., Talati, Z., Touvier, M., Galan, P., Hercberg, S., Pettigrew, S. and Julia, C. (2020), “Bulgarian consumers’ objective understanding of front-of-package nutrition labels: A comparative, randomized study”, *Archives of Public Health*, Vol. 78 No. 1, pp.1-9. https://doi.org/10.1186/s13690-020-00416-z

Ares, G., Aschemann-Witzel, J., Curutchet, M.R., Antúnez, L., Machín, L., Vidal, L., and Giménez, A. (2018), “Product reformulation in the context of nutritional warning labels: Exploration of consumer preferences towards food concepts in three food categories”, *Food Research International*, Vol. 107, pp.669-674. https://doi.org/10.1016/j.foodres.2018.03.021

Aschemann-Witzel, J., Grunert, K.G., van Trijp, H.C., Bialkova, S., Raats, M.M. *et al.* (2013), “Effects of nutrition label format and product assortment on the healthfulness of food choice”, *Appetite*, Vol. 71, pp.63-74.

Ashman, R., Patterson, A. and Kozinets, R.V. (2021), "Netnography and design thinking: development and illustration in the vegan food industry", *European Journal of Marketing*, Vol. 55 No. 9, pp. 2491-2514. https://doi.org/10.1108/EJM-02-2020-0155

Atkinson, L., and Rosenthal, S. (2014), “Signaling the green sell: The influence of eco-label source, argument specificity, and product involvement on consumer trust”, *Journal of Advertising*, Vol. 43, pp. 33-45.

Ayyub, S., Asif, M. and Nawaz, M. (2021), "Drivers of Organic Food Purchase Intention in a Developing Country: The Mediating Role of Trust", *SAGE Open*, Vol. 11 No. 3, p.215824402110450.

Ayyub, S., Wang, X., Asif, M., and Ayyub, R. (2018), "Antecedents of trust in organic foods: The mediating role of food related personality traits", *Sustainability*, Vol. 10 No. 10, p.3597

Bagozzi, R.P. (1980), “The Nature and Causes of Self-Esteem, Performance, and Satisfaction in the Sales Force: A Structural Equation Approach”, *The Journal of Business*, Vol. 53 No. 3, p.315. https://doi.org/10.1086/296088

Becker, M., Bello, N., Sundar, R., Peltier, C., and Bix, L. (2015), “Front of pack labels enhance attention to nutrition information in novel and commercial brands”, *Food Policy*, Vol. 56, pp.76-86. https://doi.org/10.1016/j.foodpol.2015.08.001

Bhatti, S. and Srivastava, R. (2003), “Participation of working women in decision-making process as consumer”, *International Journal of Consumer Studies*, Vol. 27 No. 3, pp.228-228. https://doi.org/10.1046/j.1470-6431.2003.00308_14.x

Blomqvist, K. (1997), “The many faces of trust”, *Scandinavian Journal of Management*, Vol. 13, No. 3, pp. 271-286.

Bogomolova, S., Carins, J., Dietrich, T., Bogomolov, T. and Dollman, J. (2021), "Encouraging healthier choices in supermarkets: a co-design approach", *European Journal of Marketing*, Vol. 55 No. 9, pp. 2439-2463. https://doi.org/10.1108/EJM-02-2020-0143

Bulut, Z.A. and Karabulut, A.N. (2018), “Examining the role of two aspects of eWOM in online repurchase intention: An integrated trust–loyalty perspective”, *Journal of Consumer Behaviour*, Vol. 17 No. 4, pp.407-417. https://dx.doi.org/10.1002/cb.1721

Carfora, V., Cavallo, C., Caso, D., Del Giudice, T., De Devitiis, B., Viscecchia, R., Nardone, G., and Cicia, G. (2019), “Explaining consumer purchase behaviour for organic milk: Including trust and green self-identity within the theory of planned behaviour”, *Food Quality and Preference*, Vol. 76, pp. 1-9, https://doi.org/10.1016/j.foodqual.2019.03.006

Carmines, E.G. and Zeller, R.A. (1979), “Reliability and validity assessment”. *Sage* publications.

Carruba, M. O., Caretto, A., De Lorenzo, A., Fatati, G., Ghiselli, A., Lucchin, L., & Nisoli, E. (2021), “Front-of-pack (FOP) labelling systems to improve the quality of nutrition information to prevent obesity: NutrInform Battery vs Nutri-Score”, Eating and Weight Disorders-Studies on Anorexia, *Bulimia and Obesity*, pp. 1-10.

Castelo, N., Bos, M., and Lehmann, D. (2019), "Task-Dependent Algorithm Aversion", *Journal Of Marketing Research,* Vol. 56 No. 5, pp.809-825. https://doi.org/10.1177/0022243719851788

Caswell, J.A. and Padberg, D.I. (1992), "Toward a more comprehensive theory of food labels", *American journal of agricultural economics,* Vol. 74 no. 2, pp.460-468.

Cavallo, C., Caracciolo, F., Cicia, G., and Del Giudice, T. (2018), "Extra-virgin olive oil: Are consumers provided with the sensory quality they want? A hedonic price model with sensory attributes", *Journal of the Science of Food and Agriculture,* Vol. 98, pp. 1591-1598.

Chang, H.H. and Chen, S.W. (2008), "The impact of online store environment cues on purchase intention", *Online Information Review,* Vol. 32 No. 6, pp.818-841.

Coleman, J.S. (1994), Foundations of social theory, Harvard university press.

Cronbach, L. (1951), "Coefficient alpha and the internal structure of tests", *Psychometrika,* Vol. 16 No. 3, pp.297-334.

Cronbach, L. and Gleser, G. (1959), "Interpretation of reliability and validity coefficients: Remarks on a paper by Lord", *Journal of Educational Psychology,* Vol. 50 No. 5, pp.230-237.

Cuong, D.T. (2020), "The role of brand trust as a mediator in the relationship between brand satisfaction and purchase intention", *International Journal of Psychosocial Rehabilitation,* Vol. 24 No. 6.

Daugbjerg, C., Smed, S., Andersen, L.M., and Schvartzman, Y. (2014), "Improving eco-labelling as an environmental policy instrument: Knowledge, trust and organic consumption", *Journal of Environmental Policy & Planning,* Vol. 16, pp. 559-575.

Davis, F.D. (1989), "Perceived usefulness, perceived ease of use, and user acceptance of information technology". *MIS Quarterly: Management Information Systems,* Vol. 13 No 3, pp.319-339. https://doi.org/10.2307/249008

Davis, F.D. (1993), “User acceptance of information technology: system characteristics, user perceptions and behavioural impacts”. *International Journal of Man-Machine Studies,* Vol. 38 No. 3, pp.475-487. https://doi.org/10.1006/imms.1993.1022

Davis, F.D. and Venkatesh, V. (2004), “Toward preprototype user acceptance testing of new information systems: implications for software project management”, *IEEE Transactions on Engineering management,* Vol. 51 No. 1, pp.31-46.

Dawes, R., Faust, D. and Meehl, P. (1989), “Clinical versus actuarial judgment”. *Science,* Vol. 243 No. 4899, pp.1668-1674.

Dawes, R.M. (1979), “The robust beauty of improper linear models in decision making”, *American Psychologist,* Vol. 34 No. 7, pp.571-582.

De la Cruz-Gongora, V., Torres, P., Contreras-Manzano, A., de la Mota, A.J., Mundo-Rosas, V. *et al.* (2017), “Understanding and acceptability by Hispanic consumers of four front-of-pack food labels”, *International Journal of Behavioural Nutrition and Physical Activity,* Vol. 14 No. 28.

de Magistris, T., and Gracia, A. (2008), "The decision to buy organic food products in Southern Italy", *British Food Journal,* Vol. 110 No. 9, pp.929-947.

Del Giudice, T., Cavallo, C., and Vecchio, R. (2018), “Credence attributes, consumers trust and sensory expectations in modern food market: Is there a need to redefine their role?”, *International Journal on Food System Dynamics,* Vol. 9 No. 4, pp. 307-313.

Deutsch, M. (1958), “Trust and Suspicion”, *Journal of Conflict Resolution,* Vol. 2, No. 4, pp. 265-279.

Dietvorst, B.J., Simmons, J.P. and Massey, C. (2015), “Algorithm aversion: People erroneously avoid algorithms after seeing them err”, J*ournal of Experimental Psychology: General,* Vol. 144 No. 1, pp.114-126.

Dréano-Trécant, L., Egnell, M., Hercberg, S., Galan, P., Soudon, J., Fialon, M., Touvier, M., Kesse-Guyot, E., and Julia, C. (2020), “Performance of the Front-of-Pack Nutrition Label Nutri-Score to Discriminate the Nutritional Quality of Foods Products: A Comparative Study

across 8 European Countries", *Nutrients*, Vol. 12 No. 5, p.1303. https://doi.org/10.3390/nu12051303

Ducrot, P., Méjean, C., Julia, C., Kesse-Guyot, E., Touvier, M., Fezeu, L.K., Hercberg, S. and Péneau, S. (2015a), "Effectiveness of front-of-pack nutrition labels in French adults: results from the NutriNet-Sante cohort study", *PLoS One*, Vol. 10 No. 10.

Ducrot, P., Méjean, C., Julia, C., Kesse-Guyot, E., Touvier, M., Fezeu, L.K., Hercberg, S. and Péneau, S. (2015b), "Objective understanding of front-of-package nutrition labels among nutritionally at-risk individuals". *Nutrients*, Vol. 7, pp.7106-7125.

Dunning, D., Fetchenhauer, D., and Schlösser, T. M. (2012), "Trust as a social and emotional act: Noneconomic considerations in trust behaviour", *Journal of Economic Psychology*, Vol. 33 No. 3, pp. 686-694.

Economic Development Ministry (2021), "Nutrinform Battery" (online), available at: <https://www.nutrinformbattery.it/> (Accessed 16 September 2021).

Egnell, M., Ducrot, P., Touvier, M., Alles, B., Hercberg, S., Kesse-Guyot, E. and Julia, C. (2018a), "Objective understanding of Nutri-Score Front-Of-Package nutrition label according to individual characteristics of subjects: comparisons with other format labels", *PLoS One*, Vol. 13 No. 8.

Egnell, M., Talati, Z., Gombaud, M., Galan, P., Hercberg, S., Kesse-Guyot, E. and Julia, C. (2019), "Consumers' response to front-of-pack nutrition labelling: results from a sample from The Netherlands", *Nutrients*, Vol. 11 No. 8, p.1817.

Egnell, M., Talati, Z., Hercberg, S., Pettigrew, S. and Julia, C. (2018b), "Objective understanding of front-of-package nutrition labels: an international comparative experimental study across 12 countries". *Nutrients*., Vol. 10 no. 10, p.1542.

Einhorn, H. J. (1986), "Accepting error to make less error", Journal of Personality Assessment, Vol. 50 No. 3, pp.387-395. http://dx.doi.org/10.1207/ s15327752jpa5003_8

Elshiewy, O., and Boztug, Y. (2018), “When Back of Pack Meets Front of Pack: How Salient and Simplified Nutrition Labels Affect Food Sales in Supermarkets”, *Journal Of Public Policy & Marketing*, Vol. 37 No. 1, pp.55-67. https://doi.org/10.1509/jppm.16.100

European Commission (2020), “Etichettatura dei prodotti alimentari - revisione delle norme relative alle informazioni fornite ai consumatori” (online), available at: <https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12749-Etichettatura-dei-prodotti-alimentari-revisione-delle-norme-relative-alle-informazioni-fornite-ai-consumatori_it> (Accessed 21 September 2021).

European Commission (2020b), “ Presidency Conclusions on front-of-pack nutrition labelling, nutrient profiles and origin labelling”, (online), available at: https://data.consilium.europa.eu/doc/document/ST-14048-2020-INIT/en/pdf

Fang, Y., Qureshi, I., Sun, H., McCole, P., Ramsey, E. and Lim, K.H. (2014), “Trust, satisfaction, and online repurchase intention: The moderating role of perceived effectiveness of e-Commerce institutional mechanisms”, *MIS Quarterly*, Vol. 38 No. 2, pp.407-409. https://dx.doi.org/10.2307/26634932

Finkelstein, E.A., Li, W., Melo, G., Strombotne, K., and Zhen, C. (2018), “Identifying the effect of shelf nutrition labels on consumer purchases: Results of a natural experiment and consumer survey”, *American Journal of Clinical Nutrition*, Vol. 107 No. 4, pp.647-651. https://doi.org/10.1093/ajcn/nqy014

Fornell, C. and Larcker, D. F. (1981), “Structural Equation Models with Unobservable Variables and Measurement Error: Algebra and Statistics”, *Journal of Marketing Research*, Vol. 18 No. 3, pp.382-388. https://doi.org/10.1177/002224378101800313

French Health Ministry (2021), “Nutri-Score” (online), available at: <https://www.santepubliquefrance.fr/determinants-de-sante/nutrition-et-activite-physique/articles/nutri-score> (Accessed 16 September 2021).

Fotopoulos, C. and Krystallis, A. (2003), "Quality labels as a marketing advantage: The case of the “PDO Zagora” apples in the Greek market", *European Journal of Marketing*, Vol. 37 No. 10, pp. 1350-1374.

Garcia, J.M., and Teixeira, P. (2017), "Organic versus conventional food: A comparison regarding food safety", *Food Reviews International,* Vol. 33, pp. 424-446.

Gefen, D. (2004), "What makes an ERP implementation relationship worthwhile: Linking trust mechanisms and ERP usefulness", *Journal of Management Information Systems,* Vol. 21 No. 1, pp.263-288.

Glaeser, E. L., Laibson, D. I., Scheinkman, J. A., and Soutter, C. L. (2000), "Measuring trust", *The Quarterly Journal of Economics,* Vol. 115, pp. 811-846.

Grabenhorst, F., Schulte, F.P., Maderwald, S. and Brand, M. (2013), "Food labels promote healthy choices by a decision bias in the amygdala", *Neuroimage,* Vol. 74, pp.152-163.

Granulo, A., Fuchs, C. and Puntoni, S. (2019), "Psychological reactions to human versus robotic job replacement". *Nature Human Behaviour,* Vol. 3 No. 10, pp.1062-1069.

Grove, W.M. and Meehl, P.E. (1996), "Comparative efficiency of informal (subjective, impressionistic) and formal (mechanical, algorithmic) prediction procedures: The clinical-statistical controversy", *Psychology, Public Policy, and Law,* Vol. 2 No. 2, pp.293-323. http://dx.doi.org/10.1037/1076- 8971.2.2.293

Grunert, K.G. and Wills, J.M. (2007), "A review of European research on consumer response to nutrition information on food labels", *Journal of Public Health,* Vol. 15 No. 5, pp.385-399.

Guszcza, J., Lewis, H. and Evans-Greenwood, P. (2017), "Cognitive collaboration: Why humans and computers think better together", Deloitte Review, Vol. 1 No. 20, pp.7-30.

Handi, H., Hendratono, T., Purwanto, E. and Ihalauw, J.J. (2018), "The effect of E-WOM and perceived value on the purchase decision of foods by using the Go-Food application as mediated by trust", *Quality Innovation Prosperity,* Vol. 22 No. 2, pp.112-127.

Harridge-March, S. (2006), "Can the building of trust overcome consumer perceived risk online?", *Marketing Intelligence & Planning,* Vol. 24 No. 7, pp.746-761. https://d.doi.org/10.1108/02634500610711897

Harris, J. L., Thompson, J. M., Schwartz, M. B., and Brownell, K. D. (2011), "Nutrition-related claims on children's cereals: what do they mean to parents and do they influence willingness to buy?", *Public health nutrition,* Vol. 14 No. 12, pp.2207-2212.

Haslam, N. (2006), "Dehumanization: An Integrative Review", *Personality and Social Psychology Review,* Vol. 10 No. 3, pp.252-64.

Hawley, K.L., Roberto, C.A., Bragg, M.A., Liu, P.J., Schwartz, M.B. and Brownell, K.D. (2013), "The science on front-of-package food labels". *Public Health Nutrition,* Vol. 16 No. 3, pp.430-439.

Hayes, A.F. (2017), "Introduction to mediation, moderation, and conditional process analysis: A regression-based approach". *Guilford*.

Henseler, J., Ringle, C. M., and Sarstedt, M. (2015), "A New Criterion for Assessing Discriminant Validity in Variance-based Structural Equation Modeling". *Journal of the Academy of Marketing Science,* Vol. 43 No. 1, pp.115-135.

Hersey, J.C., Wohlgenant, K.C., Arsenault, J.E., Kosa, K.M. and Muth, M.K. (2013), "Effects of front-of-package and shelf nutrition labelling systems on consumers". *Nutrition* Reviews, Vol. 71 No. 1, pp.1-14.

Highhouse, S. (2008), "Stubborn reliance on intuition and subjectivity in employee selection". *Industrial and Organizational Psychology,* Vol. 1 No. 3, pp.333-342.

Hobbs, J.E., and Goddard, E. (2015), "Consumers and trust", *Food Policy,* Vol. 52, pp. 71-74, ISSN 0306-9192,https://doi.org/10.1016/j.foodpol.2014.10.017.

Hong, I. and Cha, H. (2013), "The mediating role of consumer trust in an online merchant in predicting purchase intention", *International Journal of Information Management,* Vol. 33 No. 6, pp.927-939.

Hu, L.T. and Bentler, P.M. (1999). "Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives", *Structural Equation Modeling,* Vol. 6 No. 1, pp.1-55. https://doi.org/10.1080/10705519909540118

Janssen, M., Hamm, U. (2014), "Governmental and private certification labels for organic food: consumer attitudes and preferences in Germany", *Food Policy,* Vol. 49 No. 2, pp. 437-448.

Jarrahi, M.H. (2018), "Artificial intelligence and the future of work: Human-AI symbiosis in organizational decision making". *Business Horizons,* Vol. 61 No. 4, pp.577-586.

Jensen, M.M., Jørgensen, H., and Lauridsen, C. (2013), "Comparison between conventional and organic agriculture in terms of nutritional quality of food–a critical review", *CAB Reviews,* Vol. 8, pp. 1-13.

Jiménez, N. and San Martín, S. (2014), "The mediation of trust in country-of-origin effects across countries", *Cross Cultural Management,* Vol. 21 No. 2, pp.150-171.

Johnston, R. (2014), "Confirmatory Factor Analysis (CFA)", in Michalos, A.C. (eds), "Encyclopedia of Quality of Life and Well-Being Research", Springer, Dordrecht, pp.1194-1195. https://doi.org/10.1007/978-94-007-0753-5_524

Kasperson, R. E., Golding, D., and Tuler, S. (1992), "Social distrust as a factor in siting hazardous facilities and communicating risk", *Journal of Social Issues,* Vol. 48 No. 4, pp. 161-187.

Kassim, E., Jailani, S., Hairuddin, H. and Zamzuri, N. (2012), "Information System Acceptance and User Satisfaction: The Mediating Role of Trust", Procedia - *Social and Behavioural Sciences,* Vol. 57, pp.412-418.

Katsouri, E., Magriplis, E., Zampelas, A., Drosinos, E.H. and Nychas, G.J. (2021), "Dietary Intake Assessment of Pre-Packed Graviera Cheese in Greece and Nutritional Characterization Using the Nutri-Score Front of Pack Label Scheme", *Nutrients,* Vol. 13 No. 2, p.295.

Khan, H. (2019), "Effects of personal dispositions, familiarity and consumption situation on Western brands' packaging". *Journal of Consumer Marketing,* Vol. 36 No. 6, pp. 715-727.

Khan, H., & Lee, R. (2020), "A sociolinguistic perspective of the effects of packaging in bilingual markets", *Journal of Brand Management,* Vol. 27 No. 2, pp.130-142.

Khan, H., Lee, R., & Lockshin, L. (2015), “Localising the packaging of foreign food brands: a case of Muslim consumers in Pakistan”, *Journal of Product & Brand Management*, Vol. 24 No. 4, pp.386-398

Khan, H., Lee, R., & Lockshin, L. (2017), “The effects of packaging localisation of Western brands in non-Western emerging markets”, *Journal of Product & Brand Management*, Vol. 26 No. 6, pp.589-599

King, W. R. and He, J. (2006), “A meta-analysis of the technology acceptance model”. *Information and Management*, Vol. 43 No. 6, pp.740-755. https://doi.org/10.1016/j.im.2006.05.003.

Lang, J.T. (2013), “Elements of public trust in the American food system: experts, organizations, and genetically modified food”, *Food Policy*, Vol. 41, pp. 145-154.

Lassoued, R., and Hobbs, J.E. (2015), "Consumer confidence in credence attributes: The role of brand trust", *Food Policy*, Vol. 52, pp. 99-107.

Lewicki, R.J., and Brinsfield, C. (2011), “Framing trust: trust as a heuristic”, Framing matters: Perspectives on negotiation research and practice in communication, pp. 110-135.

Limbu Yam, B., Wolf, M. and Lunsford, D. (2012), “Perceived ethics of online retailers and consumer behavioural intentions: The mediating roles of trust and attitude”, *Journal of Research in Interactive Marketing*, Vol. 6 No. 2, pp.133-154. https://dx.doi.org/10.1108/17505931211265435

Lobb, A.E., Mazzocchi, M., and Traill, W.B. (2007), “Modelling risk perception and trust in food safety information within the theory of planned behaviour”, *Food Quality and Preference*, Vol. 18, pp. 384-395.

Logg, J.M., Minson, J.A. and Moore, D.A. (2019), “Algorithm appreciation: People prefer algorithmic to human judgment”. *Organizational Behaviour and Human Decision Processes*, Vol. 151, pp.90-103.

Longoni, C., Bonezzi, A. and Morewedge, C. (2019), “Resistance to medical artificial intelligence”, *Journal of Consumer Research*, Vol. 46 No. 4, pp.629-650.

Loughnan, S. and Haslam, N. (2007), “Animals and Androids,” *Psychological Science*, Vol. 18 No. 2, pp.116-121.

Loureiro, M.L., and McCluskey, J.J. (2000), "Consumer preferences and willingness to pay for food labelling: A discussion of empirical studies", *Journal of Food Distribution Research*, Vol. 34 No. 3, pp.95-102.

Machín, J.E., Moscato, E. and Dadzie, C. (2021), "Visualizing food: photography as a design thinking tool to generate innovative food experiences that improve food well-being", European *Journal of Marketing*, Vol. 55 No. 9, pp. 2515-2537. https://doi.org/10.1108/EJM-02-2020-0141

Mahmud, M., Islam, M., Ali, M. and Mehjabin, N. (2020), “Impact of Electronic Word of Mouth on Customers’ Buying Intention Considering Trust as a Mediator: A SEM Approach. *Global Business Review*, pp.1-15.

Mazzù, M.F., Romani, S. and Gambicorti, A. (2020), “Effects on consumers’ subjective understanding of a new front-of-pack nutritional label: A study on Italian consumers. *International Journal of Food Sciences and Nutrition*, Vol. 72 No. 3, pp.357-366.

Mazzù, M.F., Romani, S., Baccelloni, A. and Gambicorti, A. (2021a), “A cross-country experimental study on consumers’ subjective understanding and liking on front-of-pack nutrition labels”, *International Journal of Food Sciences and Nutrition*, Vol. 72 No. 6, pp.833-847.

Mazzù, M.F., Romani, S, Baccelloni, A., and Lavini, L. (2021c), “Introducing the Front-Of-Pack Acceptance Model: the role of usefulness and ease of use in European consumers’ acceptance of Front-Of-Pack Labels”, *International Journal of Food Sciences and Nutrition*, pp. 1-18. doi: 10.1080/09637486.2021.1980866

Mazzù, M.F., Romani, S., Baccelloni, A. and Simonetti, E. (2021b) “In Search of Superiority: Exploring the Effectiveness Gap of Front-of-Pack Nutritional Labels. An Assessment of Consumer’s Decision-Making Process Toward Healthier Food Choices”, *International Journal of Food Sciences and Nutrition*, Vol. 7 No. 3, pp.1-5.

McAfee, A., Brynjolfsson, E., Davenport, T.H., Patil, D.J. and Barton, D. (2012), "Big data: The management revolution". *Harvard Business Review,* Vol. 90 No. 10, pp.60-68.

Moorman, C., Deshpandé, R., and Zaltman, G. (1993), "Factors affecting trust in market research relationships", *Journal of Marketing,* Vol. 57, No. 1, pp. 81-101.

Morgan, R.M. and Hunt, S.D. (1994), "The commitment-trust theory of relationship marketing", *Journal of Marketing,* Vol. 58, No. 3, pp. 20-38.

Moschovakis, Y. N. (2001), "What is an algorithm?", in "Mathematics unlimited—2001 and beyond", Springer, Berlin, Heidelberg, pp.919-936.

Muzzioli, L., Penzavecchia, C., Donini, L.M., and Pinto, A. (2022), "Are Front-of-Pack Labels a Health Policy Tool?", *Nutrients,* Vol. 14, p. 771. https://doi.org/10.3390/nu14040771

Narciso, A., and Fonte, M. (2021), "Making farm-to-fork front-of-the-pack: labelling a sustainable European diet", *The International Journal of Sociology of Agriculture and Food,* Vol. 27 No. 1, pp. 54-70.

Nguyen, T.T.H., Nguyen, N., Nguyen, T.B.L., Phan, T.T.H., Bui, L.P. and Moon, H.C. (2019), "Investigating consumer attitude and intention towards online food purchasing in an emerging economy: An extended tam approach", *Foods,* Vol. 8 No. 11, p.576.

Nuttavuthisit, K., and Thøgersen, J. (2017), "The importance of consumer trust for the emergence of a market for green products: The case of organic food", *Journal of Business Ethics,* Vol. 140, pp. 323-337.

Otnes, C. and McGrath, M.A. (2001), "Perceptions and realities of male shopping behaviour", *Journal of Retailing,* Vol. 77 No. 1, pp.111-137. https://doi.org/10.1016/S0022-4359(00)00047-6

Packer, J., Russell, S.J., Ridout, D., Hope, S., Conolly, A. *et al.* (2021), "Assessing the effectiveness of front of pack labels: Findings from an online randomised-controlled experiment in a representative British sample", *Nutrients,* Vol. 13 No. 3, p.900.

Palan, S. and Schitter, C. (2018), “Prolific.ac—A subject pool for online experiments”, *Journal of Behavioural and Experimental Finance*, Vol. 17, pp.22-27. https://doi.org/10.1016/j.jbef.2017.12.004

Parth, S., Manoharan, B., Parthiban, R., Qureshi, I., Bhatt, B. and Rakshit, K. (2021), "Digital technology-enabled transformative consumer responsibilisation: a case study", *European Journal of Marketing*, Vol. 55 No. 9, pp. 2538-2565. https://doi.org/10.1108/EJM-02-2020-0139

Pavlou, P.A. (2003), “Consumer acceptance of electronic commerce: Integrating trust and risk with the technology acceptance model”, *International Journal of Electronic Commerce*, Vol. 7 No. 3, pp.101-134.

Richbell, S. and Kite, V. (2007), “Night shoppers in the “open 24 hours” supermarket: A profile”, *International Journal of Retail and Distribution Management*, Vol. 35 No. 1, pp.54-68. https://doi.org/10.1108/09590550710722341

Rupprecht, C., Fujiyoshi, L., McGreevy, S., and Tayasu, I. (2020), “Trust me? Consumer trust in expert information on food product labels”, *Food And Chemical Toxicology*, Vol. 137. https://doi.org/10.1016/j.fct.2020.111170

Seo, E.J., Park, J.-W. and Choi, Y.J. (2020), “The effect of social media usage characteristics on e-WOM, trust, and brand equity: Focusing on users of airline social media”, *Sustainability*, Vol. 12 No. 4, p.1691.

Shim, S., Gehrt, K.C. and Holikova, S. (1999), “Shopping orientation-based segmentation of U.S. grocery shoppers”, *Journal of Food Products Marketing*, Vol. 5 No. 2, pp.1-19. https://doi.org/10.1300/J038v05n02_01

Siau, K. and Shen, Z. (2003), “Building customer trust in mobile commerce”, *Communications of the ACM*, Vol. 46 No. 4, pp.91-94.

Siegrist, M., Cousin, M., Kastenholz, H., and Wiek, A. (2007), “Public acceptance of nanotechnology foods and food packaging: the influence of affect and trust”, *Appetite*, Vol. 49, pp. 459-466.

Siegrist, M., Stampfli, N., and Kastenholz, H. (2008), “Consumers’ willingness to buy functional foods. The influence of carrier, benefit and trust”, Appetite, Vol. 51, pp. 526-529.Talati, Z., Egnell, M., Hercberg, S., Julia, C. and Pettigrew, S. (2019), “Consumers’ perceptions of five front- of-package nutrition labels: An experimental study across 12 countries”, *Nutrients*, Vol. 11 No. 8, p.1934.

Silchenko, K. and Askegaard, S. (2021), "Powered by healthism? Marketing discourses of food and health", European Journal of Marketing, Vol. 55 No. 1, pp. 133-161. https://doi.org/10.1108/EJM-04-2018-0296

Talati, Z., Pettigrew, S., Hughes, C., Dixon, H., Kelly, B., Ball, K., and Miller, C. (2016), “The combined effect of front-of-pack nutrition labels and health claims on consumers’ evaluation of food products”, *Food Quality And Preference*, Vol. 53, pp.57-65. https://doi.org/10.1016/j.foodqual.2016.05.016

Suri, R. and Monroe, K.B. (2003), “The effects of time constraints on consumers’ judgments of prices and products”, *Journal of Consumer Research*, Vol. 30, No. 1, pp. 92-104.

Trivedi, S.K. and Yadav, M. (2020), “Repurchase intentions in Y generation: mediation of trust and e-satisfaction”. *Marketing Intelligence & Planning*, Vol. 38 No. 4, pp.401.415.

UK Health Minister (2019), “Guide to creating a front of pack (FoP) nutrition label for pre-packed products sold through retail outlets” (online), available at: <https://www.food.gov.uk/sites/default/files/media/document/fop-guidance_0.pdf> (Accessed 16 September 2021).

van der Bend, D. and Lissner, L. (2019), “Differences and Similarities between Front-of-Pack Nutrition Labels in Europe: A Comparison of Functional and Visual Aspects”, *Nutrients*, Vol. 11 No. 3, p.626.

Van, H.N., Pham, L., Williamson, S., Huong, V.T., Hoa, P.X. and Trang, P.L.H. (2020), “Impact of perceived risk on mobile banking usage intentions: trust as a mediator and a moderator”, *International Journal of Business and Emerging Markets*, Vol. 12 No. 1, pp.94-118.

Venkatesh, V. (2000), “Determinants of Perceived Ease of Use: Integrating Control, Intrinsic Motivation, and Emotion into the Technology Acceptance Model”, *Information Systems Research*, Vol. 11 No. 4, pp.342-365. https://doi.org/10.1287/isre.11.4.342.11872

Watson, D., Clark, L. A. and Tellegen, A. (1988), “Development and validation of brief measures of positive and negative affect: the PANAS scales”, *Journal of Personality and Social Psychology*, Vol. 54 No. 6, p.1063.

Who.int. (2021), “Obesity and overweight” (online), available at: <https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight> (Accessed 21 September 2021).

Wu, I.L., and Chen, J.L. (2005), "An extension of trust and TAM model with TPB in the initial adoption of on-line tax: An empirical study", *International Journal of Human-Computer Studies*, Vol. 62 No. 6, pp.784-808.

Yin, S., Wu, L., Du, L., and Chen, M. (2010), "Consumers’ purchase intention of organic food in China", *Journal of the Science of Food and Agriculture*, Vol. 9

5. Conclusions

Closing remarks

In the past years, growing attention has been given to overweight and obesity by scholars, regulatory bodies, and industry players, with the aim to solve a preventable issue that is acutely affecting public health. Policies and tools have been established to guide and inform consumers in their decision toward healthier diets, and drive companies in reformulating products with high content of specific nutrients. In this landscape, Front-of-Pack Nutritional Labels (FOPLs) have been judged helpful by consumers to achieve a more balanced dietary regime, and identified by policy-makers as a fundamental tool to support healthier food choices. However, over the course of the years and in absence of a strict mandatory regulation, European countries adopted different FOPL systems, based on divergent underlying views to how consumers should be supported, i.e., more "*guided*" vs. more "*informed*". The first option implies the utilization of "*Summary"* FOPLs to guide consumers towards the purchase of specific food products, regardless of the frequency and the dosage of specific food intake and individual consumers' health status. The second option ("*Nutrient-Specific labels*") aims at empowering consumers with appropriate, relevant and clear information to generate their personal-specific healthier diets.

Past research extensively assessed FOPL's impact on consumer decision making, also as indirect support to supra-national regulatory bodies in identifying a label that could be standardized across the EU. A large focus has been dedicated, so far, to *objective understanding*, which clarifies whether the meaning the consumer has attached to the FOPL is compatible with the meaning that the sender of the FOPL intended to communicate. In this respect, the construct was widely utilized to show that Summary labels are able to gain customers' attention and support them in correctly ranking products' nutritional quality. On the contrary, limited effort has been dedicated to *subjective understanding*, that measure what consumers derive from the perceived label information and the extent to which consumers believe they have understood the communication in a relevant way.

In this context, the present dissertation attempts to contribute to the existing literature by dealing with the issue of the impact of front-of-pack nutritional labels on food consumers' decision-making in two main directions. First, grounding on existing literature, it analyses the

important role of "*subjective understanding*" and "*liking*" in defining and comparing FOPL performances in food decision-making, an area overlooked by extant literature; second, it introduces a theoretical model, alternative to the current mainstream one, that could be used to benchmark consumers' reaction to FOPLs in different market conditions.

To the best of my knowledge, this thesis extends the literature in several ways. Specifically, the study conducted in Chapter 2, highlights the important role of *subjective understanding*, and its sub-components of *comprehensibility*, *help-to-shop* and *complexity reduction*, as well as *liking*, in benchmarking FOPL performance toward healthier and more informed food choices. Through an *in-home* experiment conducted among Italian families, the research compared a newly introduced Nutrient-Specific FOPL to the most widely utilized Summary label and demonstrated higher effectiveness of the first one in being perceived as an informative FOPL in terms of understanding of the product composition. The results remained stable both in a situation where customers have not been previously exposed to FOPL and after several weeks of FOPL exposure. The research then extends the past literature on comparison of nutritional labels' performances, mostly focused on *objective understanding*, first by showing that Nutrient-Based labels, and specifically the newly introduced FOPL NutrInform Battery, positively contribute to nudging customers to a healthier and more informed food regime. Second, it highlights that consumers' internal reactions - in terms of *subjective understanding* and *liking* – are positive to a non-directive FOPL, effective in being perceived by consumers as an informative scheme and helpful in terms of their understanding of the product composition. Third, as *liking* is an essential aspect of acceptance and use, it extends the past research by showing that consumers may like a label not only because of its colour and the symbols used, but also because they think it is easy to understand or use. In particular, consumers exposed to the NutrInform Battery, compared to consumers exposed to Nutri-Score are more in favour towards the label, more positive towards the label, and have a better impression of the label. As a side result, by analyzing for the first time the performance of the newly introduced NutrInform Battery FOPL, it also highlighted that the battery symbol, rooted in the consumer's mind in contexts other than food, as in electronic devices, is correctly interpreted when associated to food intake and strictly dependent on the graphic conditions that respondents see. Therefore, the interpretation of the stimulus is closely linked to the context in which it is presented; the food battery included in the NutrInform Battery label is then correctly interpreted by the consumers without any "*transfer-by–analogy*".

The third chapter extends and further validates the results of the first one, by delving into the question of whether results are specific to Italy or remain valid, stable and consistent in other EU countries with different socio-demo-political contexts. The study carried out in Chapter 3, according to the literature that traditionally model food decision-making, leads to the discovery that Nutrient-Specific labels over-perform Summary labels on *subjective understanding* and *liking*, in contexts with different FOPL adoption and market presence, position of the Country's governmental bodies, percentage of penetration of overweight and obesity in the population, socio-cultural background, and "volume" of the public debate and discussion on FOPLs. Through a between-subject experimental design on purchases responsible in seven EU countries, the study showed that the Nutrient-Specific label is more effective, or at worst equal, in terms of *subjective understanding* and *liking* in all tested European countries. This contributes to the past research by showing that by utilizing the same theoretical model, but focusing on *subjective understanding* and *liking*, as constructs fundamental in the decision-making and different from the *objective understanding*, a different relative performance can be observed among FOPLs, with Nutrient-Specific ones overperforming Summary labels. The results confirm that consumers perceived that more information is better[21] and they got more information from FOPLs that are not Summary-based. Second, no significant differences were present in terms of the Nutrient-Specific label performance among countries, implying a constant effectiveness and a common pattern in different socio-cultural-political contexts. Third, the study highlight that some differences exist in terms of socio-demographic variables; in line with extant literature, with a main effect of *education* and *income level* on *subjective understanding* and *liking*, and of *age* only on the sub-component of *complexity reduction*. These results on *subjective understanding* and *liking* provide a different perspective versus the outcomes of extant research on *objective understanding*, where Summary FOPL, i.e., labels that offer a synthetic view of nutrients, appear to be more effective thanks to their ability to capture attention and support the correct rank on products' nutritional quality. On the contrary, on *subjective understanding*, Nutrient-Specific ones, i.e., those who offer more information on Nutrients, are more supportive to consumers, when taking an informed food decision. In synthesis, irrespectively of different boundary conditions, when assessed through the lens of *subjective understanding* and *liking*, the performance of Nutrient-Specific FOPLs appear superior to the one of Summary labels.

[21] In some cases the abundance of information does not necessarily lead to more rational decisions, as information might be superior to individuals processing capacity (Lugli, 2018)

Given the evidences of the first two chapters, the work suggests that research based on Grunert & Wills (2007) decision-making frameworks, might not be able to offer a univocal and incontrovertible view, across different constructs, on which FOPL would be the best to be adopted at EU level to support customers toward healthier diets. Further research should then be developed to arrive either at a new unified theory or at a clearer view on which FOPL could best support consumers in their decision-making toward healthier food choices.

To this end, and relative to the existing literature, Chapter 4, based on three studies on European consumers with different levels of exposure to FOPLs, introduces an alternative framework to model food consumer decision-making mediated by FOPL, that could be used to compare FOPL performances. Grounded in the theory of acceptance, and as labels could be seen as decision support systems, the work then contributes to the development of the Front-of-Pack Acceptance Model (FOPAM) to evaluate label effectiveness in terms of their usefulness, ease of use, customers' attitude toward different FOPL, and consumers' intention to use the FOPL in their food purchase behavior, with trust toward the label as a relevant mediator. The framework leverages on the relative strength of the different labels by including the constructs of *ease to use* and of *usefulness*. Nutrient-Specific ones are, in fact, typically seen as more useful to consumers in conveying more information and facilitating healthier choices, while Summary labels are perceived as easier to be understood. The work then extends the current knowledge by understanding the antecedents of the acceptance of Front-of-Pack labels, and generalizing in contexts characterized by different previous exposure to such labels. Furthermore, it confirmed that *trust* is a major influential factor in the decision-making process, with a mediating role in the relationship between attitude and behavioral intention, an area overlooked in extant FOPL literature. Finally, the study enabled the comparison of performances of different FOPL, offering a complementary perspective to the debate on how to solve the conceptual trade-off posed by subjective and objective understanding. The study showed superior performance of the Nutrient-Based labels on all dimensions, also in cases where the connection between trust and algorithms is made transparent, by focusing on the perception of an algorithm presence behind FOPLs information.

From a theoretical perspective, the whole research also opens up to consider different paths to formation of decisions in food, when using information available from different typologies of front-of-pack nutritional labels. An alternative structure of the decision-making process,

based on acceptance, validated the idea that FOPL can be seen as *Decision Support Systems* by customers. Evidences suggest, in fact, that positive Behavioral Intentions are demonstrated by consumers when FOPLs are perceived as useful and easy to use. Those results indicate a general approach through which individuals form their intention towards food purchases, regardless of the label to whom they were exposed. This new stream applied to FOPL could be developed further, considering additional factors derived from past theoretical model of acceptance, as social influence, voluntariness of use, user involvement, or personality traits. This new venue might then contribute to the discussion on how to solve the conceptual trade-off posed by previously widely used frameworks based on *subjective* and *objective understanding*.

The central message of the thesis is that the decision on which is the best FOPL to support EU consumers' toward healthier and more informed food choices is far from being resolved and requires additional research, to the benefit of consumers, industry players and policy-makers. Nevertheless, several implications can be derived from this work also from a managerial and policy-making view.

From a managerial stand-point, reformulation of products would be not the only solution to algorithmic FOPL recommendations. Converging benefits for consumers and companies can be generated by proper communication that includes the clarification of the impact of *food portions* and of *frequency of intake* to support customers toward healthier choices while granting an appropriate dietary mix. This would not include only traditional forms of communication, but also active support through apps or other form of interactive digital media. In addition, managers can be more proactive in designing their upcoming product portfolio, taking into consideration the relative impact of specific nutrients in each product, and the expected results of combined daily diets of the use of their goods in different targets. At last, further investigation of the impact of FOPL on the supply-side of the market can be considered to develop a more thorough perspective on the impact of selecting a specific FOPL at the EU level. This would help to avoid the selection of any FOPL systems that might penalize specific products that, with the proper portion and frequency of intake, could be an part of daily meals.

In terms of policy-making, the research confirmed that in order to answer the question: "*Which is the most effective FOPL that helps customers in their more informed and healthier food choices*?" it is first necessary to clarify which underlying approach toward the end-customers is taken, i.e., individuals that need support and guidance, for which Summary labels could be

preferred, vs. individuals that are willing to build their nutritional knowledge to form their own best-personalized diet, for which Nutrient-Specific labels might be favored. It also suggests the need to enlarge the spectrum of potential theoretical frameworks to go beyond the dichotomy of *subjective* vs. *objective understanding*, in order to reduce the risk of taking wrong decisions in standardizing FOPLs across EU.

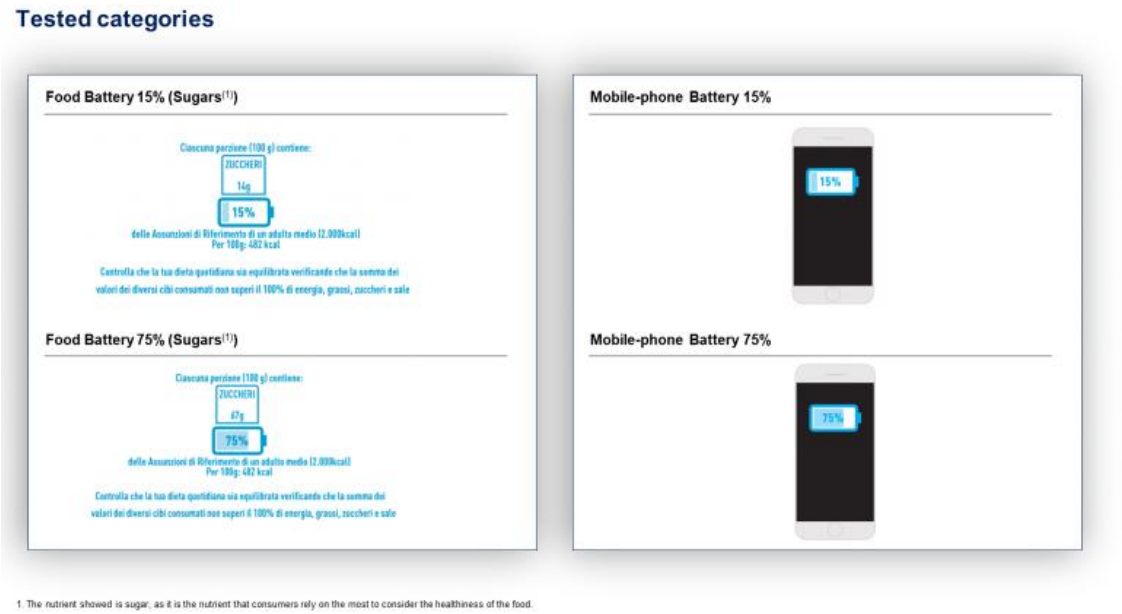
The present work is not without limitations. The sample included respondents from seven European countries; findings might then be further strengthened by including individuals of additional countries, not only to increase the validity of the results, but also as improved support to EU policy makers and industry managers. In addition, a limited number of FOPLs have been used in the experiments; exploring the effects of Summary and Nutrient-Specific Labels other than Nutri-Score and NutrInform Battery, might increase the generalizability of findings. Furthermore, the studies have approached the subject at the individual level, with focus on purchase responsible as respondents, thus not taking into consideration the role of other potential influencers in decision-making, within and outside the family. In addition, factors , as "*interest in nutrition*" and "*knowledge about nutrition*", that might affect decisions, and the use of FOPL in the process, have not been considered in the experiments. Also, the experiments included in two studies did not allow participants to access to other elements that characterize food packaging, thus limited attention has been dedicated to understand the potential interplay of FOPL with other messages present on foods products' packaging. Furthermore, in some experiments, respondents did not have the possibility to physically interact with the products and be exposed to the real-life setting of retail experiences. Moreover, experiments did not include behavioral variables to assess the full impact of FOPL along decision-making.

Finally, this research opens up to explore additional variables, currently under-researched, such as the mediating or moderating effect that could affect consumers' decision-making in food of the country of origin of products, of attitudes toward food consumption, of the impact of a dietary mix between at-home and away-from-home consumption, as well as of marketing factors, as pricing/promo structure of the offer. Another important element that should be analyzed is the potential effects of bundling FOPLs to provide the best support toward healthier and more informed food choices. Similarly, future studies could deep dive more into the differences that result when various labels are compared in the context of disclosure of the computational methods utilized form some FOPLs.

Appendix

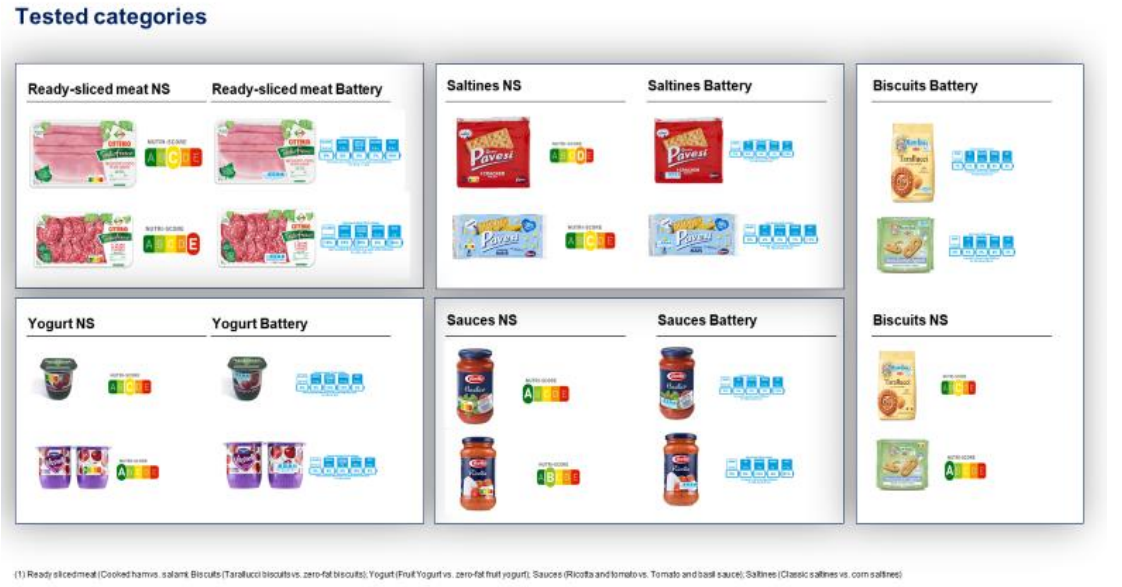
Appendix 1. Stimuli utilized in the study "Effects on consumers' subjective understanding of a new front-of-pack nutritional label: a study on Italian consumers"

Pre-test. Battery Symbol



1. The nutrient showed is sugar, as it is the nutrient that consumers rely on the most to consider the healthiness of the food.

Main test



(1) Ready sliced meat (Cooked ham vs. salami; Biscuits (Tarallucci biscuits vs. zero-fat biscuits); Yogurt (Fruit Yogurt vs. zero-fat fruit yogurt); Sauces (Ricotta and tomato vs. Tomato and basil sauce); Saltines (Classic saltines vs. corn saltines)