# The Carob as a Substitute for Cocoa in the Production of Chocolate: Sensory Analysis with Bivariate Association

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**Abstract**

*This research evaluates the degree of consumer acceptance, and or preference, for the carob, a substitute product for cocoa in the production of chocolate. It also assesses its potential as a "functional food" for celiacs, diabetics and for those intolerant to caffeine. In order to assess the degree of consumer preference for the consumption of chocolate made using carob, sensory analysis coupled with face-to-face surveys of 192 Sicilian consumers, who ate chocolate on a regular basis, were conducted, from March to May 2017. The data were processed using bivariate association analysis. 12.7% of the subjects described the aftertaste of chocolate made using carob as unpleasant and the aftertaste of chocolate made using cocoa, as pleasant or very pleasant. However, 7.1% declared that the aftertaste of the chocolate containing cocoa as unpleasant, defining the aftertaste of the carob, as pleasant or very pleasant. Some subjects also expressed a liking for both types of chocolate, declaring that they were pleasant (16.7%) or very pleasant (38.9%). Chocolate made using carob flour offers several potential health benefits compared to traditional chocolate and could find use as a functional food. This has social and economic implications for agriculture and for the cultivation of carobs. The scientific studies on this transformed product are very few. No previous research has conducted a sensory analysis on such a large sample of subjects. This research work could help to encourage the consumption of a "new chocolate" and consequently lead to the production of carob chocolate by those companies that use the fruit for other purposes.*

***Keywords:*** *chocolate; carob; cocoa; sensory analysis; bivariate association.*

## 1. Introduction

Carob is an important component of the Mediterranean flora. In the Mediterranean area, the Carob plant assumes importance from an environmental point of view, because of its ability to consolidate the ground avoiding landslides and the erosion of the soil. The cultivation of the carob tree, from an economic point of view, represents an important production in southern Italy, especially in Sicily, favouring to some extent the development of rural areas.

Carob is tolerant to heat and drought and adapts well to the Mediterranean climate (Correia *et al*., 2017. Turfani *et al*., 2017). The fruit is used both as human and animal food. It contains a high amount of carbohydrates, proteins and low levels of fat and significant amounts of potassium, calcium and polyphenols (Arribas *et al*., 2017). Therefore, it can play a significant role in human health (Custódio *et al*., 2009. Goetzke *et al*., 2014). Carob is used for pharmaceutical, food and cosmetic purposes (Kumazawa *et al*., 2002). In recent years, the scientific interest of research has focused mainly on the study of the properties of the carob pod, which is a significant source of dietary fibre, polyphenols and a surprising amount of calcium, more than three times the amount present in a cocoa pod (Kotrotsios *et al*., 2011. Yuceer *et al*., 2014). In addition, carob pods can be used as cocoa substitutes as they do not contain caffeine or theobromine (Bahry *et al*., 2017. Bengoechea *et al*, 2008). The copious research in the medical-pharmaceutical field has highlighted rather interesting results related to the bioactivity of the constituents of carob pulp. Fibres, polyphenols and tannins have been the reason of scientific interest (Martin-Diana *et al*., 2017. Migliore *et al*., 2017). These bioactive compounds have been linked to health enhancement by recognizing beneficial carob effects in different therapeutic areas, such as anti-cancer and anti-diabetes (Bates *et al*., 2000. Berk *et al*, 2017). Based on the above scientific studies, carob has been recently considered an excellent ingredient for the development of functional foods and plant supplements (Kraus, 2015. Öztürk, 2012. Pecorino *et al*., 2016). Carob pod, also called "carcao", is indicated in the diet of obese subjects (Petkova *et al*., 2017. Tounsi *et al*., 2017). Furthermore, some experiments conducted on guinea pigs have detected the cancellation of the physiological effects that lead to atherosclerosis (Sánchez-Segado *et al*., 2012. Valero-Munoz *et al*., 2014).

## 2. Analysis of the context

The major carob producing countries, as shown in the table 1, are located in Europe. According to the data provided by the 2012 FAO research, Italy and Spain have respectively a production of 23.8% and 20.4% respectively of the total amount produced. The production of carob in Italy has changed in time. In table 2 the evolution of the production of carob in Italy, particularly in Sicily is highlighted. The average carob production per plant varies depending on the soil composition and the individual production stations. In the table 3 it is possible to see

| | Area (ha) | Production (t) | (%) |
|---|---|---|---|
| Italy | 9,183 | 44,749 | 23.8 |
| Spain | 43,883 | 38,380 | 20.4 |
| Portugal | 8,274 | 31,067 | 16.6 |
| Greece | 5,284 | 20,901 | 11.2 |
| Morocco | 9,717 | 20,489 | 10.9 |
| Turkey | 2,910 | 13,972 | 7.4 |
| Cyprus | 1,353 | 10,560 | 5.6 |
| Others* | 3,564 | 7,802 | 4.1 |
| **Total** | **84,168** | **187,920** | **100** |

*Table 1*. Areas and Production of carob in major producing countries

*Source*: FAO 2012

*Algeria, Israel, Jordan, Lebanon, Mexico

| Year | 1980 - 1983 | | 1984 - 1987 | | 1988 - 1991 | | 1992 - 1995 | | 1996 - 1999 | | 2000 - 2001 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Territory | T | % | T | % | T | % | T | % | T | % | T | % |
| Ragusa | 40,800 | 70 | 36,400 | 72.8 | 23,200 | 62.7 | 29,500 | 69.9 | 25,400 | 69 | 24,500 | 63.6 |
| Siracusa | 10,500 | 18 | 8,900 | 17.8 | 9,600 | 25.9 | 9,100 | 21.6 | 7,700 | 20.9 | 10,500 | 27.3 |
| Other Provinces in Sicily | 1,800 | 3.1 | 700 | 1.4 | 600 | 1.6 | 500 | 1.2 | 500 | 1.4 | 400 | 1 |
| **Sicily** | **53,100** | **91.1** | **46,000** | **92** | **33,400** | **90.2** | **39,100** | **92.7** | **33,600** | **91.3** | **35,400** | **91.9** |
| Other Regions in Italy | 5,200 | 8.9 | 4,000 | 8 | 4,000 | 9.8 | 3,100 | 7.3 | 3,200 | 8.7 | 3,100 | 8.1 |
| **Total in Italy** | **58,300** | **100** | **50,000** | **100** | **37,400** | **100** | **42,200** | **100** | **36,800** | **100** | **38,500** | **100** |

*Table 2*. Evolution of carob production in Italy and Sicily
*Source*: Pecorino, 2001CAREX Carob Exploiters – Bioethanol Production from carob pulp

| Soil Condition | Station I | Station II | Station III | Station IV | Station V |
|---|---|---|---|---|---|
| | Up to 12 years (Kg) | From 13 to 20 years (Kg) | From 21 to 30 years (Kg) | From 31 to 40 years (Kg) | More than 41 years (Kg) |
| Excellent | 0 | 25 | 45 | 70 | 100 |
| Good | 0 | 19 | 27 | 50 | 70 |
| Bad | 0 | 8 | 20 | 30 | 50 |

*Table 3*. Annual average production per plant and in individual production stations
*Source*: Paolo Spina, 1986

this evolution. In relation to the productivity of the production, the factor "work" is worth of attention. On average, a worker can collect up to 3 tons of fruit per day, but the introduction of mechanical innovations for the collection gives much higher collection rates (Spina, 1986. Dale *et al*., 2016). The carob has left indelible traces in the history of the Sicilian territory and therefore even in its culture. The carob pulp is used in livestock zoo-technics and in the human food sector, plain or as carob flour, as an impalpable substance with a maximum moisture content of 2%. It is also used: in distilleries, for the preparation of alcohol and bioethanol; it is used in the pharmaceutical industry for its therapeutic action (anti-diarrhoea and anti-catarrhal); and even as an anti-vomit supplement. It is also used in honey extraction; human nutrition; sugar extraction; for the production of carob syrup, in the making of caramelized sugar; and even in the preparation of sorbets. The objective of this research is to focus exclusively on the use of carob as a substitute for cocoa in the preparation of "chocolate" (Spina, 1986. Monotti, 2008). Carcao is a by-product of carob flour, it used instead of cocoa in desserts, because it is cheaper and easily amalgamated with other ingredients. It is very low in fat and sodium and has almost no theobromine or caffeine (table n.4). It is widely used in the confectionery and ice cream industries (Šebečić *et al*., 2007. Spina, 1986). Table 4 shows that carob powder has a very low percentage of raw fats, around 0.7% compared to the 23.7% of cocoa powder. In carob powder there is a high percentage of natural sugars about 46%, which makes it a much healthier and a valid nutritious alternative to white sugar. It has 7% of raw fibre, which is essential for good health in the human diet. It has important percentages of iron and potassium, respectively 50 (mg/100g) and 100 (mg/100g). There is a remarkable presence of calcium, up to 300 mg per 100g. A portion of carob contains a quantity of calcium equal to that contained in a cup of cow milk (Singh *et al*., 2007). It also has small quantities of sodium 100 (mg/100g) compared to 700 (mg/100g) of cocoa. In carob powder, caffeine and the obromine are almost absent, which could hypothetically lead to excessive consumption and to "hyperactivity" problems, especially in children. The typical process for the production of carob powder is similar to that used for cocoa, with the omission of the fermentation phase (cocoa is typically fermented to produce chocolate flavours) (Poelmans *et al*., 2016). The carobs are washed, seeded, roasted and ground into powder. The roasting is fundamental because it further reduces the pH of the carob pod, unroasted carobs have a much higher pH (pH = 6.0) than roasted carobs (pH = 4.8). The toasting temperatures can vary between 80° C to 400° C, but generally, a temperature of 150 ° C is used for about 60 minutes. Carob is rich in nutrients and less caloric than cocoa and is suitable for those suffering from problems of intolerance or allergy to chocolate, because it does not contain psychoactive substances. The high content of dietary fibre makes carob a food with satisfying properties and for this reason its intake is recommended in weight losing diets. Carob pulp flour has a high-energy content, which makes it very suitable for nourishing children and sportsmen (Chinnici *et al*., 2015. Lanfranchi *et al*., 2014). This product is also suitable for vegans. Table 5 shows the "percentage price" for traditional chocolate and carob. The average price of a traditional chocolate bar of 100 g is about 3 Euros. Expressing the price data in percentages, both that of traditional chocolate and that of carob chocolate, we can see how carob chocolate has costs that are higher than cocoa chocolate, especially in the use of raw materials and labour. Carob chocolate processing involves a greater use of time than traditional chocolate. The margin should

therefore be reduced to keep the average price constant. Although the processing is more complex, because it is difficult to mix cocoa paste and carob flour, the cost of labour does not significantly affect the price, the average sales price remains constant. The average selling price of a carob chocolate bar is also around € 3.

| | Carob powder | Cocoa powder |
|---|---|---|
| Calories every100 g | 177 | 295 |
| Raw fats | 0.7% | 23.7% |
| Carbohydrate | | |
| - Natural sugar | 46% | 5.5% |
| - Fibres | 7% | 4.4% |
| Other carbohydrate | 35.4% | 38.5% |
| Proteins | 4.5% | 16.8% |
| Ash | 3.4% | 8.2% |
| Moisture | 3% | 3% |
| Iron (mg/100g) | *50* | 10 |
| Sodium (mg/100g) | 100 | 700 |
| Potassium (mg/100) | 950 | 650 |
| Caffeine | 0 | 0.16% |
| Theobromine | 0 | 1.1% |

*Table 4*. Comparative evaluation between the cocoa powder and carob powder
*Source*: Paolo Spina, 1986

| | Traditional Chocolate | Carob Chocolate |
|---|---|---|
| Ingredients | 11% | 16% |
| Labour | 10% | 15% |
| Packaging | 9.7% | 9.7% |
| Minor Costs | 14% | 14% |
| Certification | 0.3% | 0.3% |
| VAT | 10% | 10% |
| Margin | 45% | 35% |

*Table 5*. Price comparison between the traditional chocolate and carob

## 3. Objectives of the research

The interest in functional food in recent years has greatly increased; not only from the point of view of pure research, but also the market analysis has emphasized a particular interest from consumers towards these products (Lanfranchi *et al*., 2017). In fact, functional food, is part of the increasingly numerous category of products that possess properties capable of producing a beneficial effect for the consumer who eats it frequently (Schnettler *et al*., 2016). The definition of the European Food Information Council (EUFIC) has also contributed to the development and scientific research towards the discovery of new products belonging to the functional food category, which has defined them as foods that produce positive effects in the human organism that go beyond the classic nutritional effects that are part of the information on the label of the item In this study on chocolate made from carob flour, the intention is to consider this product as a possible "functional food" due to the positive effects on the consumer's health determined by the intrinsic properties of the carob. These positive effects have been highlighted by various scientific research over the years (Goulas *et al*., 2016). Therefore, this work analyses the carob in the food sector, as a substitute product for chocolate. The main objective of the research is to understand, by means of the sensory analysis conducted, if the chocolate of carob pulp flour can be considered a possible substitute for traditional chocolate made of cocoa, based on the characteristics perceived by the groups of people to whom it was given in the test. The collected data was processed using the statistical method of the bivariate association analysis. Our goal was further encouraged by the fact that Italy, and in particular the South of Italy, holds the record for carob cultivation. This could make a sizeable contribution to the local economy by exploiting the fruit in all its potential uses, cosmetics, pharmaceuticals and food. Chocolate is the most popular confectionery product in the world (Brečić *et al*, 2017). Switzerland holds the world record for its consumption, with an average of nine kilos a year per person, equivalent to 209 standard bars; Germany is in second place, Austria in third place, Ireland in fourth place, and United Kingdom in fifth place with slightly growing values. Northern Europe, with Norway, Finland and the Netherlands, shows lower performances, while in the Eastern European markets and Russia, the performances are better. Even Italians consume chocolate in large quantities. The annual "per capita" consumption of chocolate in Italy is 4 kg a year, or roughly about 11 grams a day. Data on "per capita" consumption of chocolate is added to the many motivations that drive us to promote carob and its potential use as a substitute for chocolate made with cocoa (De Pelsmaeker, *et al*., 2017).

## 4. Materials and methods

The study concentrated on a region of Southern Italy, precisely Sicily. In particular, the answers were obtained from the distribution of a questionnaire written ad hoc, with the face-to-face method, which involved 192 people randomly chosen, who had different habits but who habitually consume chocolate and who lived in the territory of Modica (Sicily) (Gary, 2017. Lanfranchi *et al*, 2015).

The questionnaire was distributed to a sample of subjects aged between 18 and 52 years old (average 29 years); they were 47.6% females and 52.4% males, 61.1% had a secondary school diploma, 23.8% had a university degree, and 15.1% had only a middle school diploma.

The period chosen was between March and May 2017. With the questionnaire, the team tried to understand if the consumer perceived, through his own senses, the differences between a sample of carob chocolate and a sample of cocoa chocolate. The questionnaire was handed out after a panel test in which the consumer was asked to taste several times both traditional cocoa chocolate and the experimental carob chocolate, specially made by a pastry chef for this research (Lanfranchi *et al*., 2016). The chocolate samples were presented in different sizes shapes, and in anonymous packaging; the first sample consisted of 50% carob pulp flour and the remaining 50% of bitter cocoa paste, the second sample was composed exclusively of cocoa paste. The cards considered valid were 126 (the remaining 66 cards were considered unreliable because the responses were incomplete). Since the examined variables were "category", an association analysis was used in order to study the possible relationships among them. The organoleptic characteristics that affected the sensory analysis were the following:

1. Looks: colour (brown or reddish), gloss (opaque or glossy) and appearance (porous or uniform).
2. Smell: Aroma (noticeable or intense).
3. Feel sensations: roundness (normal or high), fineness (dusty or flowing).
4. Taste: sweetness, bitterness and acidity (excessive, normal, low).
5. Final aftertaste: little, medium or very pleasant

A Statistical analysis was performed using SPSS Statistical Software for Windows (version 17).

## 5. Survey results

*Choice of the sample*

Sampling was performed as follows: the researchers used a "filter question" (do you usually consume chocolate?) that allowed them to identify the usual chocolate consumers. To these subjects only a simple random sampling, based on the well-known "Head or Cross" technique, was applied in order to ensure that all the subjects had the same probability of inclusion in the sample. This technique consists simply in associating beforehand the two possible choices on the two sides of the coin (head = inclusion, cross = not inclusion), then in launching it and considering extracted the choice relating to the face shown by the coin.

*Contingency tables and chi-square test*

Contingency tables were realized in order to jointly analyse the distribution of respondents according to the organoleptic characteristics of the two substances (carob and cocoa); the same were made for the comparison between males and females, for the comparison between qualifications and for the comparison between the two age groups (<30 years; ≥30 years) and for all the other variables detected.

For each contingency table, the Pearson Chi-square test for association was estimated.

Chi-Square Test for Association was applied in order to determine whether the two categorical variables were associated. That is, to determine whether the distribution of observations for one variable differs depending on the category of the second variable. This analysis was used when data was arranged in a contingency table. The null hypothesis $H_0$ assumes that there is no association between the variables (in other words, one variable does not vary according to the other variable), while the alternative hypothesis $H_1$ claims that some association does exist. The alternative hypothesis does not specify the *type* of association, so close attention to the data is required to interpret the information provided by the test. The chi-square test is based on a statistic test that measures the divergence of the observed data from the values that would be *expected* under the null hypothesis of no association. This requires the calculation of the expected values based on the data.

Assigned the threshold value α = 0.05 we have:

1) If $\alpha < 0.05$ refuses $H_0$;
2) If $\alpha \geq 0.05$, $H_0$ is accepted.

The smaller the p-value, the greater is the evidence against the null hypothesis.

| Carob colour | Cocoa colour | | | P - value |
|---|---|---|---|---|
| | Brown | Reddish | | |
| Brown | 58.7 | 11.1 | | 0.0692 |
| Reddish | 26.2 | 4.0 | | |
| Carob shine | Cocoa shine | | | P - value |
| | Opaque | Polished | | |
| Opaque | 25.4 | 42.9 | | **<0.001** |
| Polished | 23.0 | 8.7 | | |
| Carob appearance | Cocoa appearance | | | P - value |
| | Porous | Uniform | | |
| Porous | 19.0 | 42.9 | | 0.486 |
| Uniform | 9.5 | 28.6 | | |
| Carob aroma | Cocoa aroma | | | P - value |
| | Noticeable | Intense | | |
| Noticeable | 20.6 | 17.5 | | **0.044** |
| Intense | 22.2 | 39.7 | | |
| Carob roundness | Cocoa roundness | | | P - value |
| | Normal | High | | |
| Normal | 54.8 | 13.5 | | **0.003** |
| High | 17.5 | 14.3 | | |
| Carob fineness | Cocoa fineness | | | P - value |
| | Dusty | Sliding | | |
| Dusty | 32.5 | 44.4 | | 0.677 |
| Sliding | 8.7 | 14.3 | | |
| Carob sweetness | Cocoa sweetness | | | P - value |
| | Excessive | Normal | Low | |
| Excessive | 0.0 | 0.8 | 0.8 | 0.054 |
| Normal | 2.4 | 31.0 | 13.5 | |
| Low | 11.9 | 24.6 | 15.1 | |
| Carob bitterness | Cocoa bitterness | | | P - value |
| | Excessive | Normal | Low | |
| Excessive | 0.0 | 11.9 | 12.7 | **<0.001** |
| Normal | 0.8 | 43.7 | 16.7 | |
| Low | 3.2 | 9.5 | 1.6 | |
| Carob acidity | Carob acidity | | | P - value |
| | Excessive | Normal | Low | |
| Excessive | 0.0 | 3.2 | 1.6 | **0.020** |
| Normal | 0.0 | 53.2 | 11.9 | |
| Low | 3.2 | 19.0 | 7.9 | |
| Carob aftertaste | Cocoa aftertaste | | | P - value |
| | Little Pleasant | On average pleasant | Very pleasant | |
| Little Pleasant | 0.0 | 6.3 | 6.3 | **0.006** |
| On average pleasant | 1.6 | 16.7 | 11.9 | |
| Very pleasant | 5.6 | 12.7 | 38.9 | |

*Table 6.*
Contingency tables and P-value of the comparison between the organoleptic characteristics of the carob and cocoa

Table 6, which shows the contingency and p-value tables of the comparison between the organoleptic characteristics of the carob and cocoa, highlighted some important results. In particular, there was no difference in colour, appearance, fineness and sweetness between the carob and the cocoa, for which these characteristics, attributed to the two substances, can be considered superimposable (P>0.005). Significant differences, however, emerged in relation to the comparison of the other

characteristics examined, such as gloss (P<0.001), aroma (P=0.044), roundness (P=0.003), bitterness (P<0.001), acidity (P=0.020), aftertaste (P=0.006). Most of the subjects who responded to the proposed questionnaire in fact considered the cocoa to be glossy and the carob, opaque, they defined the aroma of cocoa more intense than that of the carob and the roundness of the carob higher than that of cocoa. Regarding bitterness, 24.66% of the subjects defined the carob too bitter while 96.1% defined cocoa with a normal or even low bitterness. All this implies an evaluation of the carob as excessively bitter. In addition, the acidity highlighted there are significant differences in the judgments: no subject defined excessive the acidity of cocoa or carob, while 11.9% of the respondents considered low the acidity of cocoa and normal that of the carob. Evaluating the final aftertaste, it is possible to see that there are significant differences. There were, in fact, subjects that define the aftertaste of carob not nice and the aftertaste of cocoa, on average, pleasant or very pleasant (12.7%). On the other hand, 7.1% declare the aftertaste of the cocoa unpleasant, defining the aftertaste of the carob, on average pleasant or very pleasant; there is also a conspicuous percentage of subjects that expressed a consensus for the two substances (16.7% on average pleasant and 38.9% very pleasant) (table 6). Subsequently, the comparison between the sexes (Table 7) highlighted significant differences between males and females in the evaluation of the characteristics of both the carob and cocoa. As for the carob, the brightness is the only characteristic for which males and females differ significantly in their judgment (P=0.007): the majority of female respondents (80%), in fact, define the carob as opaque. The other organoleptic characteristics examined, on the other hand, did not highlight different evaluations in the two sexes (P>0.050). The opinions of males and females related to cocoa differed significantly only in relation to the aroma (P=0.023): in fact, 53.3% of the women in the sample examined defined the aroma of cocoa as quite noticeable, while 66.7% of the males considered it intense. For the other variables, there is a homogeneity of judgment (P>0.050). The organoleptic characteristics of the carob and cocoa were subsequently examined taking into consideration the different qualifications of the respondents to the questionnaire (Table 8). From the results obtained in regards to the evaluations expressed by the subjects in reference to the carob, distinguished on the basis of the different cultural level, there are no significant differences, except for the brightness of the carob (P=0.010). In particular, it would seem that as the cultural qualification increases, there is a greater percentage of subjects that define it as opaque. In reference to cocoa, no organoleptic characteristics seem to be linked to the different cultural level of the respondents (P>0.050). Not even the distinction of subjects based on age (<30 years; ≥30 years) provided significant differences in the answers related to the properties of cocoa and carob (P>0.050): for this reason it is possible to conclude that age it is not a factor that conditions the perception of the appreciation of one for the two substances.

| Carob shine | Gender | | P - value |
|---|---|---|---|
| | F | M | |
| Opaque | 80.0% | 57.6% | **0.007** |
| Polished | 20.0% | 42.4% | |
| Cocoa aroma | Gender | | P - value |
| | F | M | |
| Noticeable | 53.3% | 33.3% | **0.023** |
| Intense | 46.7% | 66.7% | |

*Table 7.*
Comparison between the sexes in the evaluation of characteristics of the carob and cocoa

*Table 8.*
Comparison between the various titles of study in the evaluation of characteristics of the carob and cocoa

| Carob shine | Academic Qualification | | | | P - value |
|---|---|---|---|---|---|
| | Middle School | High School | 3 Year Degree | Further 2 Year Specialization | |
| Opaque | 42.1% | 72.7% | 61.9% | 100% | **0.010** |
| Polished | 57.9% | 27.3% | 38.1% | 0% | |

## 6. Conclusions

This research has shown that in relation to the degree of consumer preference of chocolate obtained from carob flour, as a potential functional food, not only has this product been associated with positive effects on health, but also the respondents have shown significant appreciation for the product. The results showed a potential use of this fruit as a possible substitute for traditional chocolate. Many consumers appreciate chocolate but they cannot eat it because of problems related to health, food intolerance or its hypocaloric characteristics. The carob, however, unlike cocoa, is richer in nutrient properties, is less caloric, contains no psychoactive substances, is rich in vitamins (riboflavin) and minerals (calcium, potassium, copper and manganese), helps the metabolic functions and supports the nervous system. Therefore, it represents a valid substitute for traditional chocolate, especially categories such as sportsmen, who can appreciate the energizing properties, children and pregnant women and above all the celiac, because it is gluten-free in contrast to cocoa. Unfortunately, to date, the carob is underestimated but it remains a fruit with a great history and it could be used to advantage to contribute to the revitalization of the local economy being a native production, especially in Sicily. The enhancement of carob cultivation could in time benefit the local Sicilian economy to leading to the reduction of cocoa imports, becoming a raw material for artisan pastry, therefore reducing the production costs of sweets and consequently increasing the margins of profits of small companies that characterize the entrepreneurial structure of these rural areas.

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## References

[1] Arribas, C., Cabellos, B., Sánchez, C., Cuadrado, C., Guillamón, E., & Pedrosa, M.M. (2017). The impact of extrusion on the nutritional composition, dietary fiber and in vitro digestibility of

gluten-free snacks based on rice, pea and carob flour blends, *Food and Function*, 8 (10), 3654-3663.
[2] Bahry, H., Pons, A., Abdallah, R., Pierre, G., Delattre, C., Fayad, N., Taha, S., & Vial, C. (2017). Valorization of carob waste: Definition of a second-generation bioethanol production process, *Bioresource Technology*, 235, 25-34.
[3] Bates, S.H., Jones, R.B., & Bailey, C.J. (2000). Insulin-like effect of pinitol, *British Journal of Pharmacology*, 130 (8), 1944-1948.
[4] Bengoechea, C., Romero, A., Villanueva, A., Moreno, G., Alaiz, M., Millán, F., Guerrero, A., & Puppo, M.C. (2008). Composition and structure of carob (Ceratonia siliqua L.) germ proteins, *Food Chemistry*, 107 (2), 675-683.
[5] Berk, E., Sumnu, G., & Sahin, S. (2017). Usage of carob bean flour in gluten free cakes, *Chemical Engineering Transactions*, 57, 1909-1914.
[6] Brečić, R., Mesić, Ž., & Cerjak, M. (2017). Importance of intrinsic and extrinsic quality food characteristics by different consumer segments, *British Food Journal*, 119 (4), 845-862.
[7] Chinnici, G., D'Amico, M., Rizzo, M., & Pecorino, B. (2015). Analysis of biomass availability for energy use in Sicily, *Renewable and Sustainable Energy Reviews*, 52, 1025-1030.
[8] Correia, P.J., Guerreiro, J.F., Pestana, M., & Martins-Loução, M.A. (2017). Management of carob tree orchards in Mediterranean ecosystems: strategies for a carbon economy implementation, *Agroforestry Systems*, 91 (2), 295-306.
[9] Custódio, L., Fernandes, E., & Romano, A. (2009). Study of the antioxidant activity of extracts from carob tree (Ceratonia siliqua L.), *Acta Horticulturae*, 841, 507-510.
[10] Dale, B.E., Sibilla, F., Fabbri, C., Pezzaglia, M., Pecorino, B., Veggia, E., Baronchelli, A., Gattoni, P., & Bozzetto, S. (2016). Biogasdoneright™: An innovative new system is commercialized in Italy. *Biofuels, Bioproducts and Biorefining*, 10 (4), 341-345.
[11] De Pelsmaeker, S., Schouteten, J.J., Gellynck, X., Delbaere, C., De Clercq, N., Hegyi, A., Kuti, T., Depypere, F., & Dewettinck, K. (2017). Do anticipated emotions influence behavioural intention and behaviour to consume filled chocolates?, *British Food Journal*, 119 (9), 1983-1998.
[12] Euromonitor International, Confectionery in Western Europe, Jan 2017.
[13] FAOSTAT, Food and Agriculture Organization of the United Nations, 2012.
[14] Gary G. Koch, Laura E. Wiener (2017). Chi-Squared Tests: Basics, Wiley StatsRef: Statistics Reference Online.
[15] Giannetto, C., Alibrandi, A., Zirilli, A., Lanfranchi, M., (2016). Egg consumption among young people: A study through the application of the logistic regression model, *American Journal of Applied Sciences*, 13 (6), 697-707.
[16] Goetzke, B.I.,& Spiller, A. (2014). Health-improving lifestyles of organic and functional food consumers, *British Food Journal*, 116 (3), 510-526.
[17] Goulas, V., Stylos, E., Chatziathanasiadou, M.V., Mavromoustakos, & T., Tzakos, A.G. (2016). Functional components of carob fruit: Linking the chemical and biological space, *International Journal of Molecular Sciences*, 17 (11), Article number 1875.
[18] Kotrotsios, N., Christaki, Bonos, E., Florou-Paneri, P., & Spais, A.B. (2011). Carobs in productive animal nutrition, *Journal of the Hellenic Veterinary Medical Society*, 62 (1), 48-57.
[19] Kraus, A. (2015). Factors influencing the decisions to buy and consume functional food, *British Food Journal*, 117 (6), 1622-1636.
[20] Kumazawa, S., Taniguchi, M., Suzuki, Y., Shimura, M., Kwon, M.-S., & Nakayama, T. (2002). Antioxidant activity of polyphenols in carob pods, *Journal of Agricultural and Food Chemistry*, 50 (2), 373-377.
[21] Lanfranchi, M., Zirilli, A., Passantino, A., Alibrandi, A., & Giannetto, C. (2017). Assessment of milk consumer preferences: identifying the choice factors through the use of a Generalized Linear Model, *British Food Journal*, 119 (12), 2753-2764.
[22] Lanfranchi, M,, Calabrò, G., De Pascale, A., Fazio, A., & Giannetto, C. (2016). Household food waste and eating behavior: empirical survey, *British Food Journal*, 118 (12), 3059-3072.
[23] Lanfranchi, M., Giannetto, C., Alibrandi, A., Zirilli, A., (2015). Analysis of the propensity to fruit consumption among young people through the cumulative proportional odds model, *American Journal of Applied Sciences*, 12 (8), 542-548.
[24] Lanfranchi, M., Giannetto, C., & De Pascale, A. (2014). Analysis and models for the reduction of food waste in organized large-scale retail distribution in eastern Sicily, *American Journal of Applied Sciences*, 11 (10), 1860-1874.
[25] Martin-Diana, A.B., Izquierdo, N., Albertos, I., Sanchez, M.S., Herrero, A., Sanz, M.A., & Rico, D. (2017). Valorization of Carob's Germ and Seed Peel as Natural Antioxidant Ingredients in Gluten-Free Crackers, *Journal of Food Processing and Preservation*, 41 (2), Article number e12770.
[26] Migliore, G., Borsellino, V., Schifani, G., Di Gesaro, M., & Schimmenti, E. (2017). Good, safe and fair: Quality perception and consumer demand of locally produced beef in Southern Italy, *New Medit*, 16 (3), 39-46.
[27] Monotti, C. (2008). Future chocolate market growth in four EU countries, *British Food Journal*, 110 (7), 671-690.
[28] Öztürk, M., Seçmen, Ö., Gucel, S., & Sakcali, S. (2012). An overview of economic and medicinal importance of carob plants (Ceratonia siliqua L.) in the Mediterranean basin, *Acta Horticulturae*, 964, 197-204.
[29] Pecorino, B., Signorello, M., & Trovato, G. (2016). How sensory attributes affect consumption of functional foods? Evidences from a consumer test in Sicily (Italy), *Quality - Access to Success*, 17, 113-117.
[30] Pecorino, B. (2001). CAREX *Carob Exploiters* – Produzione di Bioetanolo da polpa di carrube.
[31] Petkova, N., Petrova, I., Ivanov, I., Mihov, R., Hadjikinova, R., Ognyanov, M., & Nikolova, V. (2017). Nutritional and antioxidant potential of carob (Ceratonia siliqua) flour and evaluation of functional properties of its polysaccharide fraction, *Journal of Pharmaceutical Sciences and Research*, 9 (11), 2189-2195.
[32] Poelmans, E., & Rousseau, S. (2016). How do chocolate lovers balance taste and ethical considerations?, *British Food Journal*, 118 (2), 343-361.
[33] Sánchez-Segado, S., Lozano, L.J., de los Ríos, A.P., Hernández-Fernández, F.J., Godínez, C., & Juan, D. (2012). Process design and economic analysis of a hypothetical bioethanol production plant using carob pod as feedstock, *Bioresource Technology*, 104, 324-328.
[34] Schnettler, B., Adasme-Berríos, C., Grunert, K.G., Márquez, M.P., Lobos, G., Salinas-Oñate, N., Orellana, L., & Sepúlveda, J. (2016). The relation between attitudes toward functional foods and satisfaction with food-related life, *British Food Journal*, 118 (9), 2234-2250.
[35] Šebečić, B., Vedrina-Dragojević, I., Vitali, D., Hečimović, M., & Dragičević, I. (2007). Raw materials in fibre enriched biscuits production as source of total phenols, *Agriculturae Conspectus Scientificus*, 72 (3), 265-270.
[36] Singh, G., Arora, S., Sharma, G.S., Sindhu, J.S., Kansal, V.K., & Sangwan, R.B. (2007). Heat stability and calcium bioavailability of calcium-fortified milk, *LWT - Food Science and Technology*, 40 (4), 625-631.
[37] Spina Paolo, Il carrubo. *Edagricole*, Bologna, 1986.
[38] Tounsi, L., Karra, S., Kechaou, H., & Kechaou, N. (2017). Processing, physico-chemical and functional properties of carob molasses and powders, *Journal of Food Measurement and Characterization*, 11 (3), 1440-1448.
[39] Turfani, V., Narducci, V., Durazzo, A., Galli, V.,& Carcea, M. (2017). Technological, nutritional and functional properties of wheat bread enriched with lentil or carob flours, *LWT - Food Science and Technology*, 78, 361-366.
[40] Valero-Munoz, M., Martin-Fernandez, B., Ballesteros, S., Lahera, V., de las Heras, N. (2014). Carob pod insoluble fiber exerts anti-atherosclerotic effects in rabbits throughsirtuin-1 and peroxisome proliferator-activated receptor-γ coactivator-1α, *Journal of Nutrition*, 144 (9), 1378-1384.
[41] Yuceer, H., & Vehbi, B.O. (2014). Adaptive reuse of carob warehouses in Northern Cyprus, *Open House International*, 39 (4), 65-77.