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# Technological and nutritional importance of carob.

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A R T I C L E I N F O

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*carob,*
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A B S T R A C T

The aim of this work is to revalue carob (*Ceratonia Siliqua L*) from two different perspectives. The first is to gain knowledge about the rheological behaviour of wheat flour enriched with multiple amount of carob powder (1%, 2% and 3%). The second is to measure and analyse the antioxidant effect of carob powder on sheep meat. This study revealed that carob powder has a significant antioxidant effect and that replacing wheat flour with a 1% concentration of this powder does not affect the rheological behaviour of the flour. In fact, it not only optimises the physicochemical parameters of the flour (P/L), but also the baking improvers.

## 1.Introduction

Carob is one of the well-spread fruit crops among populations of Mediterranean countries (Bouhrem *et al.*, 2020). Its production and consumption have increased significantly in recent years. They are commonly used in the making of cooked pekmez juices and powdered drinks. Nonetheless, the use of the whole fruit for human consumption is limited due to its high tannin content, which leads to astringency (Bate-Smith, 1973; Karkacer and Artk, 1995). It is considered as a new raw material at low prices for livestock (Guemour *et al.,* 2010). The inclusion of carob powder in the rabbit diet showed better fermentation in the caecum with a positive effect on post-weaning health (Guenaoui *et al.,* 2019). The pulp is the main component of the locust bean pod (90%), but currently only the seeds (10%) are used industrially to obtain locust bean gum. Carob pulp is considered to be a good source of bioactive components such as phenolic compounds, some of which exhibit antioxidant (Makris and Kefalas 2004; Sebai *et al.* 2013) and antiproliferative activities (Corsi *et al.* 2002).

Possessing crucial technological properties, carob trees could solve several dilemmas related to economic and technological imperatives in the agro-food sector. For this reason, the main objective of this work is the valorisation of the carob tree to make it a noble resource for the food industry. The main objective of the study was projected from two different perspectives, the first being based on the important protein fraction of carob, including albumin and the second was to estimate the antioxidant of this fruit. Therefore, the first aim of the study was to replace wheat flour with different percentages of carob powder. This results in a reduction in economic importation of a widely consumed product (common wheat) and gluten.

The second goal was to implement the antioxidant activity of carob phenols as a natural antioxidant for sheep meat preservation; a

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product considered a nutritionally important source for its protein content (Sayd et al., 2014), vitamins (Duchene *et al.*, 2016) and reasonable fat content (Geay *et al.,* 2002).

Moreover, meat products industry uses synthetic antioxidants to extend meat conservation time; such as butylated hydroxyanisole (BHA), butylated hydroxytoluene (BHT), and propyl gallate (PG). With submersion of the harmful effects on the health of the consumer. The demand for the use of natural antioxidants is increasing (Lorenzo *et al.,* 2018).

## 2. Sample and material :

*2-1. sample preparation*

Ripe carob pods (*Ceratonia Siliqua L*) were harvested from selected carob populations in the Guelma region, Eastern Algeria. These pods were thoroughly ground and then protected from light for further analysis and preparation. A sample of sheep meat (*Logissimus Dorsi*) was collected from the butcher shop of a market in the Mostaganem region, Western Algeria, and then ground in a household electric grinder. First of all, the nutritional and technological suitability for industrial and artisanal processing of carob is to be measured, this measurement is elaborated by determining primary and secondary metabolites. Second, the powder from the whole carob milling is mixed with wheat flour in proportions of 1%, 2% and 3%. Finally, concentrations of 5%, 10% and 15% of carob powder is applied to minced meat of the leg and then measuring of the freshness index is elaborated in stepwise at time intervals of 1 hour, 2 hours and 4 hours.

*2-2. Methods*

*2-2-1. Determination of dry matter :* A drying of 1 g of carob powder was carried out in an oven at the temperatures of 100°C to 105°C, under atmospheric pressure until a practically constant mass is obtained. To avoid any recovery of moisture, it is advisable to place it in a desiccator.

*2-2-2. Determination of mineral content :* The incineration of 2 g of carob powder in the muffle furnace, in porcelain crucibles, at a temperature of 900 °C was carried out and stopped only when the colour of the residues became grayish-white, which will turn into a white colour after cooling.

*2-2-3. Determination of moisture content:* Water content of the core was determined by the standardised method, "NF T 60-305, June (1976)", described by AFNOR (1982) and which consists of parboiling carob powder at a rate of one gram 105 ± 05 ° C for 24 Hours.

*2-2-4. Protein determination:* The principle is based on the mineralisation of organic matter by sulphuric acid in the presence of a catalyst, followed by alkalisation of the reaction products and then distillation and titration of the ammonia released (Kjeldahl, 1883).

The Kjeldahl nitrogen in the sample is first converted to ammonia by acid digestion in a mineralisation batch. The addition of a strong base releases ammonia, which is then carried away by water vapour and then trapped in a solution of boric acid. The ammonia is then determined by a solution of sulphuric acid of known titration. The equivalence point is identified by the change in colour of an indicator. The crude protein content of the product shall be obtained by multiplying the obtained value when determining the nitrogen content by the factor 6.25.

*2-2-5. Determination of fat content:* Extraction by organic solvents (Hexane), specific to the determination of the fat content was carried out with a Soxhlet type apparatus. At the end of the extraction, it can be assumed that all the fat was transferred to the solvent.

*2-2-6. Determination of total phenolic content:* A test portion of 0.25 g of carob powder is macerated in 100 ml of acetone / water mixture (70% v / v) for 90 minutes, at room temperature. Adapted by Benchikh et al. (2014) the total phenolic compounds (TPC) of the extracts were evaluated using the Folin-Ciocalteu method (Singleton and Rossi, 1965).

*2-2-7. Determination of peroxidation value:* The most commonly measured secondary products of lipid oxidation are aldehydes. Thiobarbituric acid (TBA) reacts with malonaldehyde (MDA) to form a pink and/or yellow complex with maximum absorption at a wavelength of 532 nm. It also reacts with other aldehydes resulting from the oxidation of long-chain PUFAs (polyunsaturated fatty acids). The concentration of TBA-reactive substances (sr-TBA), expressed as MDA equivalent, is evaluated by reading the absorbance with the visible spectrophotometer of the sr-TBA extracted from meat samples with a trichloroacetic acid (TCA).

*2-2-8. Alveographic analysis:* A dough preparation with a constant water content (wheat flour and salted water) enriched with carob powder was elaborated. It is the formation of specimens at a well-determined thickness of dough. It is a biaxial extension, by bubble swelling, of laminated dough specimens. The graphic recording of pressure variations within the bubble as a function of time, the appreciation of the characteristics of the paste and the surface of the alveograms obtained are read directly by the device: they are calculated from the five curves obtained. The analysis is made in the laboratory of a mill in the region of Mostaganem- Algeria.

*2-2-9. Statistical analysis of results:* The data collected in this fully randomised design were analysed for variance (SAS Institute, 2008) and treatment means were separated using the Duncan multiple range test. Contrasts with a single degree of liberty were used to test the overall effects of substitution. The level at which differences were considered significant was $p < 0.05$.

## 3. Results and discussion

*3-1. Primary and secondary metabolites*

The results of the chemical composition of primary and secondary metabolites of carob are shown in Table 1.

**Tab. 1.** Chemical composition of primary and secondary metabolites of carob .

| Chemical composition in metabolites Primary | Quantity (%) |
|---|---|
| Humidity | 14.76 ± 0.27 |
| Mineral matter | 2.45 ± 0.16 |
| Dry matter | 85.23 ± 0.27 |
| Crude protein | 8.60 ± 0.25 |
| Crude lipid | 4.48 ± 0.24 |
| Chemical composition of Secondary metabolites | Mg/g DM |
| Total phenols (CPT) | ± 0.21 |

According to our results (Table 1), the amount of water present in the fruit is estimated at 14%. These results are similar to those of Yousif Alghzawi, (2000). While those of Youssef *et al,* (2013) are inferior to ours. These authors explain this difference by the influence of pedoclimatic factors, the variety of carob tree and the prerequisites for analysis (time interval between collection and assignment of analyses).

*3-1-1. Lipids:* The lipid content (Table 1) is slightly higher than that reported by Youssef *et al,* (2013), who only included the powder from the pulp of the carob bean, while the seed contains the highest proportion of lipids.

*3-1-2. Mineral matter:* The mineral content of carob powder result (Table 1) is consistent with that of Youssef *et al,* (2013), these levels are explained by the geographic origin of the samples, including climatic conditions and sedaphic properties of the soils. According to Kamal *et al,* (2013), sulfur predominates at 17,577.80 mg/kg, followed by phosphorus at 2,255.21 mg/kg, calcium at 22,123 mg/kg and trace elements: iron, manganese, zinc and copper.

*3-1-3. Crude protein:* The protein content (Table 1) is slightly higher than that of Youssef *et al,* (2013)). Research by Yousif and Alghzawi, (2000) indicates that aspartic acid was the most abundant amino acid (4.13 mg/ g dry weight) followed by alanine (2.76 mg/g dry weight). On the other hand, the amount of the cysteine-methionine pair was notably low, lysine (0.26 mg/g dry weight) rather than the previous amino acid pair was the least abundant amino acid. Ayaz *et al,* (2009) state that the amino acid composition of carob is acceptable and well balanced except lysine, compared to the standard protein level reported by the WHO (World Health Organization, 2007).

*3-1-4. Total phenols:* Our results in Table 1 are consistent with those of Avallone et al. (1997) and Owen et al. (2003). They are slightly lower compared to those found by Ortega *et al,* (2011). This difference is interpreted by geographical origin, variety and degree of ripeness. Youssef *et al,* (2013) found that carob phenols consist of 11 components including chlorogenic acid and caffeic acid, both of which are antioxidants that inhibit formation mutagenic and carcinogenic N-nitrosating compounds in vitro (Han *et al.*, 2007). In addition, certain phenolic acids contribute to the fight against various types of cancer, including breast, lung and stomach cancers (Kumazawa *et al.*, 2002).

### 3-2. Estimation of the freshness index of minced sheep meat

Oxidation degree of meat is illustrated in Table 2.

**Tab. 2.** Malondialdehyde MDA content (mg/kg) in minced sheep meat.

| Shelf life Treatments | After 1 hour | After 2 Hours | After 4 hours |
|---|---|---|---|
| *Control meat* | 0.97 ± 0.41a | 1.82 ± 0.19a | 1.97 ± 0.4a |
| *(Meat processed at 5 %)* | 0,679 ±0.037of | 0,879 ± 0.067b | 0.932 ± 095b |
| *(Meat processed to 10 %)* | 0,542 ± 0.019f | 0,702 ± 0d | 0,781 ± 0.036c |
| *(Meat processed at 15 %)* | 0,182 ± 0.021g | 0,566 ± 0.009f | 0,609 ± 0.011ef |

*(n = 15 ± cartype) (a,b, c, d, e are homogeneous groups at p < 0.05)*

According to our results, the use of 15% carob powder has a greater oxidation inhibitory effect compared to other concentrations. According to (Brand-Williams *et al.*, 1995) free radicals and antioxidant compounds form a complex which slows down the appearance of oxidation products. The antioxidant activity of phenolic compounds is largely dictated by their molecular structure and concentration. (Marian Naczk *et al.*, 2003) adds that this complicates both the determination of the antioxidant activity of complex mixtures of phenolic compounds extracted from plants and the interpretation of experimental data during the application of the latter on meat.

Furthermore (Irene Albertos *et al.*, 2015) confirms that carob seeds possess antioxidant activity capable of significantly inhibiting the oxidation of lipids (peroxidation value (PV), hydroperoxides, TBARS, rancid odour), loss of α tocopherol, colour modification and protein oxidation (Carbonyls). Some researchers such as Bastida *et al,* (2009), suggest that it would be more interesting to test this vegetable powder on meats with a high level of unsaturated fatty acids. Nevertheless, further studies are needed to evaluate its antimicrobial properties and potential health benefits.

### 3-5. Rheological and characteristic study of flour enriched with carob powder

The characterisation of the control flour and those enriched with carob powder are shown in Table 3.

**Tab. 3.** Characteristics of control flour and those enriched with carob powder .

| Samples | Protein % | Humidity % | Ashes % |
|---|---|---|---|
| *Control flour* | 11,28 ± 0.125a | 14,59 ± 0.022a | 0,59 ± 0.036b |
| *Flour fortified to 1 %* | 11,29 ± 0.149a | 14,52 ± 0.022ab | 0,62 ± 0.075b |
| *Flour fortified to 2 %* | 11,25 ± 0.089a | 14,4 ± 0.062b | 0,66 ± 0.036a |
| *Flour fortified to 3 %* | 11 ± 0.361a | 14,4 ± 0.069b | 0,66 ± 0.026a |

(n = 15 ± cartype) (a,b, c, d, e are homogeneous groups at p < 0.05).

The characteristics of the control flour and those enriched with carob powder are expressed in Table 3 and show no significant difference ($p > 0.05$) between control flour and fortified flour with carob powder in terms of protein and ash. On the other hand, the moisture content of the control flour is significantly higher ($p < 0.05$) than that of enriched flours, since the dry matter brought back by the carob lowers the humidity.

The results of the rheological characteristics of the control and fortified flour are given in Table 4.

**Tab. 4.** Rheological characteristics of control and enriched flour .

| W and (W/L) Fortified flours | W(baking force) | P/L (toughness, extensibility and deformation work) |
|---|---|---|
| *Control flour* | 164 ± 4.82a | 0.49 ± 0.048b |
| *Flour enriched to 1 %* | 167 ± 1.32a | 0.62 ± 0.035a |
| *Flour fortified to 2 %* | 160 ± 7.05a | 0.54 ± 0.045ab |
| *Flour fortified to 3 %* | 160 ± 3.5a | 0.36 ± 0.045c |

(n = 15 ± cartype) (a,b, c, d, e are homogeneous groups at p < 0.05)

With regard to baking strength (W), no significant differences are reported between the different flour. The P/L ratio of flour fortified to (1%) is significantly greater ($P < 0.05$) than that of the control with an estimated difference ratio of 20.97%.

We conclude that the inclusion of (1%), (2%) and (3%) of carob powder in wheat flour has no impact on rheological properties. Nevertheless, baking strength (W) and P/L ratio are more important in flour fortified with (1%). This improvement is probably due to the gelling properties of the pectins and galactomannan gum that carob contains.

## 4. Conclusion

Carob powder has an oxidation-inhibiting effect on sheep meat which was explained by the significant lowering of the MDA content recorded in meat treated with carob powder. In addition, the 15% concentration had the greatest antioxidant effect. In this case; it is possible to incorporate carob powder as an industrial-scale preservative of meat products as long as it does not require purification technologies or extraction of phenols to benefit from the its antioxidant effect. Moreover, substitution of common high consumed wheat flour with a concentration of 1% carob powder improves the rheological parameters of the flour.

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