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Processing and characterization of carob powder

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Abstract

The possibility of processing roasted carob powder using different time–temperature combinations has been studied. The physical and chemical characteristics of the prepared carob powders were also examined. The most acceptable roasted carob powder was obtained by roasting kibbled carob at 150°C for 60 min. The roasted carob powder contained 9.00, 5.82, 2.84 and 0.74% moisture, protein, ash and fat, respectively. The carob powder had 38.7% total sugar, 7.24% fiber and 3.75% tannins. The powder had a pH of 4.81, its water activity was 0.33 and its particle size was 150 μm. © 2000 Elsevier Science Ltd. All rights reserved.

1. Introduction

The carob tree (*Ceratonia siliqua)* is native to the Mediterranian region and the best varieties are those cultivated in Syria and Palestine (Brand, 1984). In Jordan, carob trees are estimated at about 200,000 (Mhaisen, 1991) and are found widely uncultivated in many places, especially in the north. An increase in carob plantations has been reported in the last few years. Such increase, however, is attributed to the drought resistance characteristics of carob.

Carob is used in many Arab countries to make a popular drink which is consumed mainly in the month of Ramadan. Carob is also used in preparation of special traditional types of Arabic confectionery (Mhaisen, 1991). In western countries, carob powder is produced by deseeding of carob pods, yielding of kibbled carob, followed by roasting and milling of the kibbled carob (Anon, 1979; Binder, Coit, Williams & Brekke, 1959; Blendford, 1979; Nyerges, 1978;). The produced carob powder is sold in USA and other Western countries in health food stores as a substitute or extender for cocoa.

The chemical composition of carob has been studied by many investigators (Binder et al., 1959; Blendford, 1979; Calixto & Canellas, 1982; Craig & Nguyen, 1984; MacLeod & Forcen, 1992; Nyerges, 1978;). Carob pods are characterized by a high sugar content (more than 50%) with about 75% or more of those sugars as sucrose (Binder et al., 1959; MacLeod & Forcen, 1992). So, carob is a natural sweetener with a flavor and appearance similar to chocolate. Carob is often used as a chocolate or cocoa substitute (Brand, 1984; Nyerges, 1978). Such usage is attributed to the fact that carob has the advantage of being caffeine and theobromine-free whereas chocolate and cocoa contain relatively high amounts of these two antinutrients (Craig & Nguyen, 1984).

The Jordanian imports of cocoa and chocolate have increased significantly in recent years and reached more than 3 million Jordanian Dinar (Mhaisen, 1991). Roasting studies of carob and preparation of carob powders as well as the characterization of the prepared powders are the major objectives of this study.

2. Materials and methods

2.1. Selection and preparation of samples

The carob pods were purchased from the local market. Mature and defect-free pods were selected, washed, dried and then kept in polyethylene bags in a deep freezer until used. Cocoa powder, containing 23% fat, was also purchased to be used as a reference sample.

2.2. Measurement of carob pods

Ten randomly selected pods were used for measuring weight, length, width and thickness. Length was measured using a measuring tape; width and thickness by

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using vernier calliper, whereas weight was taken using a top-loading balance . The ratio of seeds and pulp weight was calculated by kibbling (deseeding) 30 randomly selected pods.

2.3. Preparation of carob powder

The carob sample was divided into three portions; the first portion was kibbled then milled to a particle size of 150 μm (to pass 32-mesh seive). The second portion was kibbled and roasted using different time-temperature combinations. The third portion was roasted without kibbling using the same time–temperature combinations as used for the second portion. Roasting was carried out at 150°C for 30, 60, and 90 min and at 200° C for 30, 60 and 75 min. Roasting at 150 and 200°C was carried using an air oven (Fisher, Isotemp, USA). Whole and kibbled carob pods were also roasted at 250°C for 10, 15 and 30 min at 400°C for 10, 15, and 20 min and at 450°C for 5, 10 and 15 min. Roastings at 250, 400 and 450°C were carried out in a home oven. The roasted whole pods, after being kibbled, as well as the roasted kibbled pods, were milled to a particle size of 150μm then remilled to 500 μm (to pass a 100-mesh seive). The prepared carob powders were kept in polyethylene bags and stored in a deep freezer at –18°C until used.

2.4. Sensory evaluation of the roasted carob powders

A multiple comparison preference test, as recommended by Larmond (1982), was used to evaluate the prepared carob powders. Twenty semi-trained panellists from the Nutrition and Food Technology Department of the University of Jordan were used in the evaluation. Hot milk drinks flavored with the prepared pods were used to evaluate the carob powders. In this sensory test a reference or control sample containing cocoa powder was used . The panellists were asked to judge if the hot milk carob flavored samples were better, comparable or inferior to the control. A nine point scale was used in this test where extremely better than the control was given 1 and extremely inferior than the control was given 9 and samples judged to be equal to the control were given the score 5.

The hot milk drink formula contained 14 g whole milk powder, 4 g sugar, 80 ml water and 2 g roasted carob powder. The control sample contained 2 g cocoa powder instead of carob powder. The carob powder that gained the highest scores was characterized physico-chemically.

2.5. Chemical and physical properties of the carob powder

Moisture, crude protein, crude fat, pH, ash, tannin and crude fibre were determined by established methods (AOAC , 1995). Sugars were determined using the Berlin Institute method (AOAC). Water activity of the carob powder was determined using the standard salt solutions method as recommended by Dalton (1966). The particle size of the carob powder was determined according to the seive analysis method (Samuel, 1970). The color of the carob powder was measured using an extracting procedure (Maier & Schiller, 1960).

2.6. Statistical analysis

The obtained data were analysed statistically using a special statistical analysis system (SAS) package at the Computer Center of the University of Jordan. Values of all parameters were presented as mean ±S.D. Analysis of variance (ANOVA) with randomized complete block design was used in statistical analysis of the sensory tests. Duncan's Multiple Range test was performed to determine differences between the various treatment means (SAS Institute, 1987).

3. Results and discussions

3.1. Measurements of carob pods

Results of carob pod measurements are shown in Table 1. The mean weight of whole pods was 31.8 g while length, width and thickness were 123.4, 19.5, and 9.3 mm, respectively. The pulp to kernel ratio was 4:5 whereas seeds made up 20% of the total pod weight.

Data obtained from other studies showed that the carob pods ranged from 100 to 200 mm long, 20 to 50 mm wide, 9 to 10 mm thick and 20 to 40 g in weight (Blenford, 1979). The results obtained in this study, however, are in agreement with the literature. It is well established that the physical measurements of the whole carob pods indirectly indicate the quality of those pods. It was observed in this study that, the higher the thickness, the higher the pulp to kernel ratio and consequently the better quality of pods.

3.2. Roasting of carob

Roastings of whole as well as kibbled carob pods at different time–temperature combinations are shown in

Table 1
Measurements of Carob Pods[a]

Characteristics	Mean ± S.D.
Weight (g/pod)	31.84 ± 3.24
Length (mm)	123.38 ± 12.38
Width (mm)	19.53 ± 2.35
Thickness (mm)	9.33 ± 1.38
Seeds (g/100 g pod)	20.00
Pulp to kernel ratio	4:5

[a] Mean of 30 pods.

Table 2. Preliminary studies showed that roasting, at temperatures less than 80°C, required more than 24 h before noticeable changes in color and flavor were observed. This process might be considered drying rather than roasting. On the other hand, temperatures exceeding 400°C were difficult to control, due to rapid changes in color and flavor. The production of burnt flavour, however, was more noticeable in the prepared carob powders using such high temperatures. It was also observed that sieving of kibbled carob to eliminate fines before roasting aided in reducing formation of burnt flavor.

From more than 20 types of roasted carob powder prepared, only nine types were found to be acceptable as judged by a preliminary multiple comparison preference test which was carried out to exclude roasted carob powder types that have little chance of acceptance.

3.3. Sensory evaluation of the roasted carob powders

Nine roasted carob powders were evaluated sensorially using the multiple comparison preference test. The three powders that gained the highest scores (T1, T7 and T4) (Table 2) were re-evaluated to choose only one powder to be physico-chemically analysed and then incorporated in the preparation of cake, ice cream and candy bar (the second part of this study). However, kibbled carob roasted at 150°C for 60 min gained the best scores and accordingly was characterized in terms of its physical and chemical properties.

The statistical analysis (Tables 2 and 3) revealed that roasting time significantly affected ($P < 0.05$) the quality of the prepared carob powders. Increasing roasting time had a negative effect on the sensory quality of the produced powders as judged by the panelists. Significant differences ($P < 0.05$) were also noticed between the different types of carob powders (Table 3) . On the other hand, the panelists and the interactions between panellists and treatments did not show any significant differences.

3.4. Chemical and physical properties of the carob powder

Results of the chemical and physical properties of the roasted carob powder (that achieved the highest sensory scores, i.e roasted for 60 min at 150°C), non-roasted carob powder, and cocoa powder are presented in Table 4.

The moisture content of roasted carob powder (9.00%) was lower than that of the non-roasted carob

Table 2
Sensory evaluation mean scores[a] of milk drink containing different kinds of roasted carob powders

Trial	Type	Particle size during roasting	Temperature of roasting °C	Time of roasting (min	Sensory mean scores
1	T1	Kibbled	150	60	6.69a[b]
	T2	Pods	250	30	5.38b[c]
	T3	Kibbled	150	30	3.38c
	T4	Pods	150	30	6.94a
2	T5	Pods	250	10	4.81b
	T6	Kibbled	400	10	3.75c
	T7	Pods	400	10	6.25a
3	T8	Pods	300	10	3.75b
	T9	Kibbled	250	60	2.69c
	T1	Kibbled	150	60	5.94a
4	T7	Pods	400	10	4.75b
	T4	Pods	150	30	4.44c

[a] Mean of duplicate.
[b] Means with different letters in the same trial column differ significantly (P < 0.05).
[c] Scores above 5 are considered better than control, while scores below 5 are inferior to control.

Table 3
Analysis of variance of the roasted carob powders sensory tests

Source of variation	Degree of freedom	Sum of squares	Mean square	F value
Replicates	1	0.003	0.003	0.0028
Treatments	2	42.034	21.017	19.037
Panelists	19	24.187	1.273	1.153
Treatments× Panellists	38	119.814	3.153	2.860
Error	49	54.096	1.104	
Total	119	240.12	0.834	

powder (11.1%). The moisture values for the carob powder prepared in this study were, however, higher than those reported by other researchers for carob powders (Blenford, 1979; Brand, 1984). The higher moisture content may have contributed to the difficulties experienced during milling of carob pods.

Table 4 shows that the pH value of the roasted carob powder (4.81) was significantly different ($P < 0.05$) from that of the non-roasted carob powder (5.96). Such results might be attributed to caramalisation during the roasting process, where the formation of by-products and other intermediates, such as pyruvic acid, might be expected (Lee, Kagan, Jawarski & Brown 1990). The pH value of cocoa powder was on the alkali side (7.1) due to the Dutch process during manufacturing (Meursing, 1983).

It is clearly evident from Table 4 that the fat, ash, tannin and protein values of roasted and non-roasted carob powders are lower than those of cocoa powder. These results, however, agree with other earlier findings on carob powder (Blenford, 1979). The low fat content may support the assumption that carob could be considered a natural healthy food. On the other hand, carob powder is free from the two anti-nutrients caffeine and theobromine (Craig & Nguyen, 1984) and has higher levels of crude fiber, compared with cocoa powder. This might be considered as an advantage from a nutritional point of view qualifying it as a good replacer or extender for cocoa powder in many food items.

Regarding sugar content, it is obvious that carob powder, either roasted or not, contained about 20-fold more sugar than cocoa powder. As a result, carob and carob products could be considered natural sweeteners, for formulating food products. Sucrose is the dominant sugar found in carob (about 70% of total sugar). Roasting, however, caused some reduction in sugar content of carob. Such reduction might be attributed to the Mailard reaction and caramelisation during roasting (Blenford, 1979; Calixto & Canellas, 1982).

Large and significant variation could be observed in the water activity (a_w) values of the three studied powders (Table 4). The lower a_w values might account for the high stability of these powders (Chaung & Toledo, 1974). Achieving a low a_w for the carob powder (less than 0.33) similar to that of cocoa powder (0.18), would improve their successful milling for smaller particle sizes (less than 100 μm).

The non-roasted carob powder had a lighter color than the roasted carob powder and cocoa powder and this is expected since the latter two products were susceptible to Mailard reactions and caramelisation. A close similarity could be observed between the color of the roasted carob powder and that of the cocoa powder. Such results may explain the possibility of indistinguishable substitution of up to 25% of cocoa powder with carob powder in many food products (Anon, 1979; Blenford, 1979; Nyerges, 1978).

It is clear from Table 4 that the carob powders, either roasted or not, are characterised by a larger particle size than that of the cocoa powders which might adversely affect their incorporation in formulated food products. The failure to reach a smaller particle size for the carob powder might be ascribed to their high sugar, moisture and a_w values compared with cocoa powder.

4. Conclusions

Varying of processing conditions and product variables, i.e. time, temperature, moisture content and particle size will produce different types of carob powder. Roasting temperatures below 80°C were not effective in producing acceptable carob powder, whereas temperatures

Table 4
Chemical and physical properties of carob and cocoa powders

Composition[a]	Non-roasted carob powder	Roasted carob powder	Cocoa powder
Moisture	11.07a[b] ± 0.38	9.03b ± 0.05	2.51c ± 0.34
Crude protein	5.54b ± 0.38	5.82b ± 0.08	22.9a ± 0.38
Crude fat	0.30b ± 0.04	0.74b ± 0.12	22.88a ± 0.63
Ash	2.79b ± 0.22	2.48b ± 0.13	6.40a ± 0.63
Crude fibre	10.99a ± 0.51	7.24b ± 0.14	4.93c ± 0.50
PH	5.96b ± 0.02	4.81c ± 0.03	7.10a ± 0.05
Tannin	3.15c ± 0.03	3.75b ± 0.12	4.91a ± 0.13
Total sugars	45.0a ± 0.30	38.7b ± 0.51	2.16c ± 0.94
Reducing sugars	13.6a ± 0.25	11.6b ± 0.35	ND[c]
Non-reducing sugars	31.4a ± 0.13	27.1b ± 0.43	2.16c ± 0.94
Water activity	0.45a ± 0.02	0.33b ± 0.01	0.18c ± 0.03
Color	0.21 ± 0.02	0.85 ± 0.01	0.70 ± 0.02
Particle size (μm)	500	150	70

[a] Means ± standard deviation.

[b] Means having the same letters in the same row are not significantly different (P > 0.05).

[c] Not detected.

above 400°C were difficult to control. The best time–temperature combination for roasting of kibbled carob was at 150°C for 60 min according to sensory results. The prepared carob powder was characteristic of a high sugar content, relatively moderate protein content and low fat content compared with cocoa powder. Additionally, it is well established that carob is free of the two anti-nutrients found in cocoa, i.e. caffeine and theobromine. Accordingly, such characteristics may qualify carob powder as a natural healthy food that could be used efficiently as a replacer or extender for cocoa powder in many foods.

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