Research Article

The Appropriate Drying Parameters for Producing Wild Carob (*Ceratonia siliqua L.*) Cocoa Powder Substitute

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Aziz Caliskan*
Norhidayah Abdullah
Noriza Ishak
University Technology MARA (UiTM), Faculty of Hotel and Tourism Management, 40450, Shah Alam, Malaysia
Azizcaliskan96@gmail.com

Suleyman Engin
University of Mardin Artuklu (MAU), Faculty Of Tourism, Gastronomy And Culinary Arts, 47200, Artuklu, Mardin
chefsuleyman@gmail.com

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Abstract

Extant literature has suggested that the demand for chocolate is increasing at a geometric rate while cocoa production is increasing at an arithmetic rate. Hence it is predicted that a point will be reached where the production of cocoa will not accommodate the demand of chocolate production. Therefore, it is rational to seek a suitable alternative that could substitute cocoa. Therefore, this study is focused on utilizing Cypriot Wild Carob Powder (WCP), which is mostly used for animal feeding or thrown away as cocoa powder substitute. The study conducted physiochemical experiments (milling yield, water activity, and colour analysis) on roasting times of 10, 20, and 30 mins at 90, 110, and 130 ° C were tested to determine the optimum drying time and temperature to produce WCP. The results from physical analysis showcased that WCP, which was roasted at 130 °C for 30 mins, showed relatively better water activity (68.9%) and milling yield (85.3%) as compared to the control sample (cocoa powder). However, in terms of water activity and colour analysis, WCP, which was roasted at 130 °C for 30 mins, had the closest value to its control sample (cocoa powder). Hence, this sample was elected as the most suitable for producing WCP as substitute cocoa powder.

Keywords:

Wild Carob Powder; Physical Analysis; Roasting Temperature

1 Introduction

Carob (*Ceratonia siliqua* L.) tree is one of the most essential commodities of Mediterranean regions due to its high nutrients. Cyprus is an island cited east of the Mediterranean Sea. They are two kind of carob trees in Cyprus which are cultivated and wild carob (MOA, 2008). The manufacturers mostly interested in using cultivated carob to produce syrup, and candies etc. but wild carob either use for animal feeding or throwing away (Christou et al., 2019). Therefore, even though wild carob is underutilized nonetheless still high in active compound and especially rich in dietary fibre (El-Shatnawi & Ereifej, 2001). Dietary fibre is extremely essential component for reducing obesity due to the increasing viscosity of stomach and this will reduce the appetite to eat more (Goulas et al., 2016). Obesity is a physical condition whereby an individual's Body Mass Index (BMI) surpasses 30 (Saeedi et al., 2019). This condition, may contributed by bad eating habits, encompassing the intake of high energy dense food products include chocolate bars (Hall et al., 2011). Cocoa, the main material used in the preparation of chocolate bars contain high fat content led to high energy-dense food. Hence, the aim of this study is to utilize wild carob (*Ceratonia Siliqua* L.) to produce wild carob powder which is low in fat and high in fibre with presence of active constituents to produce a low energy dense as an alternative for chocolate bars which may be beneficial for chocolate lovers without compromising their health.

The challenge of powder production is to ensure that the shelf life and quality are met (Moreira, Chenlo, Torres, Rama, & Arufe, 2015). Appropriate drying and roasting parameters affect the quality of the powder. Roasting temperature and time are important parameters because moisture loss and water activity must be reduced below 0.6 a_w to ensure physicochemical and microbiological stability (Dhankhar & Tech, 2013). therefore, this preliminary study was initiated to determine the appropriate roasting temperature and time to produce wild carob powder that meets the quality standards of the powder. Furthermore, study done by Boublenza et al. (2017), mentioned that the roasting temperature is extremely important for aroma of the product. Same author found that at the higher temperature carob manifest coffee like aroma, while at the lower temperature carob manifest cocoa like aroma. As a result, in this preliminary study, wild carob was subjected to various roasting parameters including different roasting times and lower temperatures. The quality of wild carob powder was determined by water activity, grinding efficiency and colour analysis.

2 Methodology

2.1 Materials

The matured 5 kg wild carob (Ceratonia siliqua L.) was collected from Tatlisu, Famagusta, Cyprus. The collection process was organised with the Department of Cooperative Association of the Ministry of Agriculture in August 2021. Only mature and physically undamaged wild carob samples were used in this study. Collected wild carob samples were cleaned from dust and insect. The cleaned carob samples were placed in vacuum sealer plastic storage bags, and they will be carried to the laboratory at a temperature of 28-30 °C. A commercial cocoa powder was purchased from a local market in Famagusta, Cyprus as control.

2.2 Preparation of wild carob powder

Three different roasting times (10,20 and 30 mins) and 3 different roasting temperatures (90, 110, and 130°C) were tested to obtain the appropriate roasting time and temperature for wild carob powder production. Approximately 100 g of wild carob in triplicate were subjected to oven (Rational selfcookingcenter, model 102, GERMANY) at 90, 110, and 130 °C for 10, 20 and 30 mins.

After the roasting process, all of the roasted samples were removed from their respective ovens and placed on trays for the following phase, which entailed the grinding process. The roasted wild carob was placed into the conventional food grinder (PANA-MX-800) and ground for 1 minute. Finally, after grinding, the roasted wild carobs were sieved with a conventional sieve with a particle size of 0.18-0.20 mm. The obtained wild carob powders were kept in an air-tight container at the temperature of 4 °C prior to analysis.

2.3 Physicochemical Analysis

The physiochemical properties of wild carob powders were studied to determine milling yields, water activity, and colour analysis. These analyses were conducted thrice.

2.3.1 Milling Yields Analysis

The milling yield analysis was done to find the percentage of yield of the drying process WCP after it had dried. It is based on two major factors, including the weight before drying and its weight after drying, using the following formula (Berghofer et al., 2003).

$$\text{Yield \%} = \frac{\text{Weight before drying } - \text{Weight after drying}}{\text{Weight before drying}} \text{ x } 100\%$$

2.3.2 Water Activity

Approximately 5 g of WCP and cocoa powder were transferred in separate plates, and their a_w was estimated at 25 ± 0.2 °C using Rotronic HygroLab, HP23-AW-A Set, USA (AOAC, 2000; Rothschild et al., 2015).

2.3.3 *Colour Analysis*

Approximately 8 g of WCP and cocoa powder were placed into a petri dish, and colour analysis was performed using a Hunter colorimeter (Hunter Colour-Flex, CFLX 45-2, Hunter Associates Laboratory, Inc., Reston, VA, USA).

According to the CIE scale in triplicate using L*, a*, b* colour space. The L* value calculating lightness (0)/white (100), the a* value calculating green (-)/red (+) and the b* value calculating blue (-)/yellow (+). The Hunter colorimeter was calibrated before the analysis using colour standard (white and black) ceramic tiles obtained from the supplier. The assessments were carried out through a D-65 illuminant and 10° assessors. The colour was measured in 3 arbitrary sections.

2.3.4 *Statistical Analysis*

The mean and standard deviation values were determined for all experiments. The normality test was conducted on the data prior to statistical analysis of variance (ANOVA) among the samples, using Excel Software version 2016.

3 Findings

This section elucidates the results from analyses such as yield analysis, water activity, and colour analysis for all samples containing wild carob powders and cocoa powder (control sample). Appropriate discussion, analysis and comparisons are also included in this section.

3.1 Milling Yields Analysis

Table 1: The milling yield results of wild carob powders roasted at different temperatures and times.

Drying Temperature (°C)	10 mins	20 mins	30 mins
90	32.36 ± 0.08^{bC}%	32.43 ± 0.24^{bC}%	27.39 ± 0.07^{aC}%
110	27.33 ± 0.24^{aB}%	27.34 ± 0.14^{aB}%	27.34 ± 0.08^{aB}%
130	27.32 ± 0.16^{aB}%	27.32 ± 0.07^{aB}%	27.39 ± 0.11^{bC}%
Control Sample	4 ± 0.42^{aA}%	4 ± 0.42^{aA}%	4 ± 0.42^{aA}%

'a-c' indicates a significant difference between drying time samples and 'A-B' indicate a significant difference between drying temperature samples at $p < 0.05$.

Control sample = cocoa powder.

First of all, for the wild carob powder preparation only pulp part of the wild carob was required. Hence before the roasting phase of wild carob powder, seed of the wild carob was removed.

The seed percentage of wild carob samples was recorded as 24.4±1.06% of the 100 gram of wild carob sample used. Based on the milling yield analysis, a total of 9 carob samples (i.e., each weighing 100g) were utilized at separate roasting times set for 10, 20 & 30 mins at varying roasting temperatures of 90, 110, & 130 °C, with results showcasing that time and temperature had effect on the milling yield percentage of wild carob powders (Table 1). Comprehensively, when the wild carob powder samples were roasted at 90°C, 110 °C and 130 °C temperatures, the resultant yielding percentage ranged between 27.39±0.07%-32.36±0.08%, 27.34±0.24%-27.34±0.08%, 27.32±0.16%-27.39±0.11%, respectively. As shown in table1, there is a insignificant reduction in milling yield value for roasting temperatures at 110 °C and 130 °C across the various drying times as compared that at 90 °C. It is evident that samples roasted at 90 °C for 10 and 20 mins had a higher percentage yield. Intuitively, this could be attributed to having a higher moisture content in the wild carob powders of which a drying temperature of 90 °C for 10 or 20 mins is not sufficient to dehydrate all its water content.

However, it is apparent from the obtained results that drying at a temperature of 90°C for 30 mins removed the maximum moisture content of the wild carob led to the highest milling yield percentage. The effectiveness of this dehydration temperature and time (i.e., 90 °C for 30 mins) is showcased by the insignificant decline in the milling yields values of the wild carob samples roasted at 110°C and 130°C for 10, 20, and 30 mins as indicated by lower milling yield percebtage. According to Counce et al. (2005), the milling yields of rice power is lowered by the effect of high-temperature treatment. This is in agreement with a study on the effect of stir-frying on oat powder milling conducted by Qian et al. (2020), revealing that increasing the stir-frying duration led to the decrease of milling yields of oat flour from 45.40 ± 0.42 in 10 minutes to 42.78 ± 0.79 in 40 minutes due the development of congregates of starch after long periods of frying, which led to an increase in intermolecular interactions in oat endosperm. It can be assumed that the lower value of the yield percentage of wild carob powder dried at 110 and 130 °C is because of the high roasting temperature. In summary, the milling yields of wild carob samples outweighs that of cocoa, which is supported by Abenyega & Gockowski (2001), who stated that only 4% of cocoa powder can be produce from cocoa due to the high fat content of the cocoa beans.

3.2 Water Activity

The Food and Drug Administration measure the water activity (a_w) usually within three to five minutes using easy-to-use instruments as it aid in identifying potentially dangerous foods (FDA, 2014). According to Dhankhar & Tech (2013), microbial organisms do not exist below a water activity level of 0.60. Hence, acknowledging the fact that a water activity level higher than 0.80 facilitates the growth of microorganisms plays an important role in the shelf-life of many food products including powders. Besides temperature and pH level, water activity is regarded as one of the most important factor affecting of microbial growth (Doyle, 2001). As a result, to ensure a better quality and longer shelf-life of the product, the determination of water activity in powder can be considered as more important than its moisture content due to the microorganisms are not able to grow less than value of 0.6 a_w (Doyle, 2001).

Table 2: Water activity of wild carob roasted at different temperature

Drying Temperature (°C)/ Drying time	10 mins	20 mins	30 mins
90	$0.504{+}0.001^{cC}$	$0.471{+}0.001^{bC}$	$0.431{+}0.001^{aC}$
110	$0.468{+}0.001^{cB}$	$0.438{+}0.001^{bB}$	$0.404{+}0.001^{aB}$
130	$0.427{+}0.001^{cA}$	$0.403{+}0.001^{bA}$	$0.382{+}0.001^{aA}$
Control Sample	$0.554{+}0.001^{aD}$	$0.554{+}0.001^{aD}$	$0.554{+}0.001^{aD}$

'a-c' indicates a significant difference between drying time samples and 'A-B' indicate a significant difference between drying temperature samples at $p < 0.05$.

Control sample = cocoa powder.

In this experiment, all samples (i.e., wild carob roasted at 90, 110, and 130°C for 10, 20, 30 mins, and cocoa powder) were in accordance with the standard of water activity. The result of water activity of wild carob samples roasted at 90 degrees temperatures for 10, 20, and 30 mins were 0.504+0.001 a_w, 0.471+0.001 a_w, and 0.431+0.001 a_w respectively. While water activity result of wild carob samples roasted at 110 degrees temperatures for 10, 20, and 30 mins were 0.468+0.001 a_w, 0.438+0.001 a_w, and 0.404+0.001 a_w respectively. Additionally, findings of water activity of wild carob samples which were roasted at 130 degrees temperatures for 10, 20, and 30 mins were 0.427+0.001 a_w, 0.403+0.001 a_w, and 0.382+0.001 a_w respectively. However, the results revealed that all roasting temperatures used to roast the wild carob did produce significantly different (p <0.05) values of water activity.

Overall, wild carob powder that was roasted at 130°C for 30 mins showed significantly lower water activity of 0.382+0.001 a_w than all other wild carob powders and the control sample (i.e., cocoa powder). Considering the control value (0.554+0.001 a_w), the water activity value obtained from wild carob powder, roasted at 130°C for 30 mins is most suitable for shelf-life.

3.3 Colour Analysis

The colour of the wild carob powders is an essential quality parameter for consumers' preferences. Table 4.3 shows the result from the colour analysis (lightness (L*), redness (a*), and yellowness (b*)) obtained from wild carob powder samples which roasted under temperatures of 90, 110, and 130 °C for 10, 20, and 30 mins.

Table 3: L* value of wild carob powders

Materials	Wild Carob		
Drying Temperature (°C)	**10 mins**	**20 mins**	**30 mins**
90	51.72±0.07^{bD}	51.76±0.03^{bD}	51.21±0.05^{aC}
110	49.58±0.03^{cC}	49.05±0.27^{bC}	48.48±0.02^{aB}
130	48.84±0.02^{cB}	46.17±0.07^{bB}	41.38± 0.31^{aA}
Control Sample	41.95±0.40^{aA}	41.95±0.40^{aA}	41.95±0.40^{aA}

'a-c' indicates a significant difference between drying time samples and 'A-B' indicate a significant difference between drying temperature samples at $p < 0.05$.

Control sample = cocoa powder.

Table 3 shows that the lightness (L*) values of wild carob powder samples which were roasted for 10 mins at 90, 110, and 130 °C were 51.72±0.07, 49.58±0.03, and 48.84±0.02, respectively. While lightness (L*) values of wild carob powder samples roasted for 20 mins at 90, 110, and 130 °C were 51.76±0.03, 49.05±0.27, and 46.17±0.07, respectively. Finally, lightness (L*) values of wild carob powder samples roasted for 30 mins at 90, 110, and 130 °C were 51.21±0.05, 48.48±0.02, and 41.38± 0.31, respectively. Table 4.3 shows that with increasing roasting temperature and time, the lightness of the wild carob powder samples gradually decreased. This decrease can be attributed to sugars caramelization, the assembly of the Maillard reaction products such as melanoidins, and the intensity of the brown pigments which are related to the expansion of wild carob kibbles, mirroring the brownish colour of wild carob powder especially at higher roasting temperature and time (i.e., 130 for 30 mins) (Mounir et al., 2021). Nadeem et al. (2017), also noted that the colour of cultivated carob was indirectly proportional to roasting temperature and time. In terms of the control sample (i.e., cocoa powder), significant difference was recorded between control sample and wild carob powder samples which were roasted at 90°C (10, 20, and 30 mins), 110 °C (10, 20, and 30 mins), and 130 (10 and 20 mins). However , the lightness (L*) value was 41.95±0.40 which is not significantly different ($p > 0.05$) from the L* value of the wild carob powder roasted at 130 °C for 30 min. however,

Table 4: redness (a*) value of wild carob powders

Materials	Wild Carob		
Drying Temperature (°C)	**10 mins**	**20 mins**	**30 mins**
90	5.01±0.03^{aA}	6.02±0.02^{bA}	6.21±0.02^{cA}
110	6.31±0.02^{aB}	6.64±0.05^{bB}	7.16±0.03^{cB}
130	8.85±0.03^{aC}	9.69±0.03^{bC}	9.90± 0.10^{cC}
Control Sample	11.56±0.23^{aD}	11.56±0.23^{aD}	11.56±0.23^{aD}

'a-c' indicates a significant difference between drying time samples and 'A-B' indicate a significant difference between drying temperature samples at $p < 0.05$.

Control sample = cocoa powder.

Table 5: yellowness b* value of wild carob powders

Materials	Wild Carob		
Drying Temperature (°C)	**10 mins**	**20 mins**	**30 mins**
90	14.31±0.03^{aB}	14.34±0.01^{Ab}	14.38±0.01^{bA}
110	14.18±0.33^{aB}	14.48±0.09^{AC}	14.69±0.02^{bB}
130	15.30±0.02^{bC}	15.45±0.04^{cD}	13.75± 0.13^{aC}
Control Sample	13.77±0.04^{aA}	13.77±0.04^{aA}	13.77±0.04^{aC}

'a-c' indicates a significant difference between drying time samples and 'A-B' indicate a significant difference between drying temperature samples at $p < 0.05$.

Control sample = cocoa powder.

The a* values of the wild carob powder roasted at 90 °C for 10, 20, and 30 mins were 5.01±0.03, 6.02±0.02, and 6.21±0.02, respectively. The a* values of the wild carob roasted at 110 °C for 10, 20, and 30 mins were 6.31±0.02, 6.64±0.05, and 7.16±0.03, respectively. Finally, the a* value of the wild carob powder roasted at 130 °C for 10, 20, and 30 mins were 8.85±0.03, 9.69±0.03, and 9.90±0.10, respectively. The a* values of the wild carob powders were significant difference ($p < 0.05$) within samples and between the samples of wild carob powder. The b* values of the wild carob powders roasted at 90 °C for 10, 20, and 30 mins were 14.31±0.03, 14.34±0.01, and 14.38±0.0,1 respectively. The b* values of the wild carob powders roasted 110 °C for 10, 20, and 30 mins were 14.18±0.33, 14.48±0.09, and 14.69±0.02, respectively. Lastly, the b* values of the wild carob powders roasted 130 °C for 10, 20, and 30 mins were 15.30±0.02, 15.45±0.04, and 13.75± 0.13, respectively. In summary, the b* values of the wild carob powder within the samples with roasting temperatures of 90 and 110 °C for 10 and 20 mins had non-significant difference ($p > 0.05$), but wild carob powders that were roasted at 130 °C had a significant difference ($p < 0.05$) withing samples. The results of the a* and b* values of the control sample (i.e., cocoa powder) were 11.56±0.23, and 13.77±0.04, respectively, indicating that the a* value of this sample was significantly higher than all the wild carob powder samples. Whereas the b* value of the control sample was significantly lower than all the wild carob powder samples. As shown in **Error! Reference source not found.**, the a* and b* values are increasing when the L* is decreasing. Higher redness (a*) and yellowness (b*) values are caused by a darker colour (i.e. lower lightness L* value) of a given sample (Mounir et al., 2021; Reddy et al., 2017). Hence, this result can explain the increasing a* and b* values of the wild carob powders.

4 Conclusion

The water activity, colour analysis, and milling yield analysis of the wild carob powders prepared at different temperatures and roasting times had a generally acceptable level. Among all, WCP, which was roasted at 130 °C for 30 mins, showed the most acceptable results. This treatment had significantly lower water activity as compared to the other treatments and control samples, and had no significant difference in terms of lightness (L*) as compared to the control sample (cocoa powder). Therefore, 130 °C and 30 mins were found to be the appropriate roasting parameters to produce the wild carob powder as substitute cocoa powder for chocolate industries.

5 About the author

Aziz Caliskan currently doing his PhD at the Department of Hotel and Tourism Management, Universiti Teknologi MARA. Caliskan does research in Physicochemical, Microbial, Sensorial as well as Behavioural studies on the food products.

Norhidayah Abdullah currently works at the Department of Food Service Management, Universiti Teknologi MARA. Norhidayah does research in Plant Fertilization, Animal and Human Nutrition and Food Science. Their current project is 'innovation in teaching'.

Noriza Ishak currently works at the Department of Culinary & Gastronomy, Universiti Teknologi MARA. She researches Food Heritage and Food Innovation. Her current work is on the state's traditional food consumption.

Suleyman Engin currently works at Department of Gastronomy, University of Mardin Artuklu. Engin does research in Food Production, Gluten-Free, and Anatolian Cuisine.

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