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Physicochemical Properties of Cypriot Wild Carob (Ceratonia siliqua L.) Powder as Cocoa Powder Substitute

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Abstract: This study used Cypriot Wild Carob Powder to serve as an alternative for cocoa powder. The study conducted various physiochemical experiments, encompassing milling yield, water activity, colour analysis and proximate analysis. We noted that the milling yield, water activity, and dietary fibre content of WCP are higher than cocoa powder. Conversely, cocoa powder had moisture content (2.1 ± 0.37), ash (3.42 ± 0.05), protein (4.66 ± 0.78), fat (not detected), carbohydrate (46.7 ± 0.87) and energy (205 Cal), that were higher than WCP (6.56 ± 0.24), (4.63 ± 0.03), (24.3 ± 0.66) & (14.5 ± 0.15), (426 Cal) respectively. Hence, it is evident that the high dietary fibre and low energy values of WCP make it a suitable substitute for cocoa powder-based products to alleviate the concern of obesity.

Keywords: Cocoa Substitute, Wild Carob, Proximate Analysis, Physical Analysis.

1. Introduction

Cyprus is an island located across the Mediterranean Sea, with its geographical and historical profile highly esteemed and regarded as one of the world's finest tourist destinations [1]. As a result, the nation channels most of its resources towards tourism, making it one of its primary sources of revenue. However, due to the nation's engrossed devotion towards tourism and its climate, other economic avenues such as agricultural practices are given less attention [2]. Notwithstanding, Cyprus is endowed with carob plants that blossom despite the climate conditions. Carob (Ceratonia siliqua L.), which is a native plant in Cyprus, has two species, cultivated and wild carob. The cultivated species are grown mainly in maquis areas. In contrast, the wild species grow almost everywhere in Cyprus, including the Akamas region, Episkopi, Lemesos forest, Lefkara, Kalavasos, Stavrovouni, Kyrenia mountain range, and Karpaz peninsula[3].

The carob fruits contain varying amounts of simple sugars, proteins, fat, alkaloids, and dietary fiber. Furthermore, the carob fruit contains a minimum amount of theobromine and caffeine levels, which are unwanted in some foods[4], [5]. The active compounds found in the carob fruit are known as polyphenols, which are treatments for cancer, obesity, diabetes, diarrhea, and hyperlipidemia[6], [7]. In addition, carob is also a low energy-dense food product that is suitable for remedying the issue of obesity due to its inherent low-fat content. The two sets of carob species (cultivated and wild) are both grown in Cyprus, with the wild species characterized by relatively thinner structures, housing a large proportion of seeds than the cultivated species[8]. However, due to the high sugar content inherent in cultivated carob fruits, it is used as the main ingredient for making syrup, desserts, biscuits, and other processed beverages. Conversely, wild carob has seldom usage in Cyprus, only primarily harnessed for animal feeding or unused, hence, heralding its minimal utilization, resulting in its low valuation[9]. However, despite the underutilization and undervaluation of wild carob, studies by[10], conducted on wild carob, showcased the exceptional health benefits of carob, distinguished by its healthy sugar, low-fat content, dietary fibers, and bioactive molecules (polyphenols and cyclitols). Hence, this shows that the potential nutritional value intrinsic to wild carob will be more beneficial when harnessed for food production rather than being discarded. Furthermore, wild carob could be the cheapest and most suitable alternative for cocoa in chocolate production due to its low-fat content high dietary fiber.

As compared to cocoa, the dietary fiber content of the carob is higher, which only indicates its worth. Generally, dietary fibers are categorized into two, encompassing soluble and insoluble fibers. The majority of soluble dietary fibers ferment faster in the colon and are more attainable to hydrolytic enzymes, while the insoluble fibers are excreted with the stool, thus having the effect of increasing stool[11]. The Food and Drug Administration (FDA) and the European Food and Safety Authority recommend an intake of 25 g per day of dietary fiber, which is made of 6 g of soluble fiber in each dose [12]. Furthermore, because of the low-energy density of dietary fiber and its water-retaining capacity, it increases the viscosity of the stomach content and delays hunger sensations (i.e., appetite to eat) as a result of the slowdown of hunger sensation, the need to eat decreases, which is a critical factor in avoiding obesity, that happens to be one of today's issues[13].

According to the World Health Organisation (WHO), obesity is a rising concern that continues to proliferate, recording about 650 million adults as obese and more than 1.9 billion as overweight globally in 2016. Based on the trend of events, records suggest that the prevalence of obesity had tripled worldwide between 1975 and 2016 [14]. Obesity, a physical condition that occurs when an individual's Body Mass Index (BMI) surpasses 30, is a condition attributed to bad eating habits, arising from the intake of high energy-dense food products such as chocolate products [15]. The high energy content present in cocoa products is due to the presence of cocoa, which is the main material in their preparation[16]. Hence, motivated by these concerns, this study has opted to focus on wild carob, which is a low energy-dense plant, to determine its efficacy of usage as a substitute for cocoa powder.

2. Methodology

2.1 Materials

Matured wild carob (Ceratonia siliqua L.) was collected from Tatlisu, Famagusta, Cyprus. The collection process was organized 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 insects and were placed in vacuum-sealed plastic storage bags, and they were 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 the control sample.

The chemical agents used in this study were supplied by Sigma Integrated Chemical Shah Alam, Selangor. These include petroleum ether, concentrated sulfuric acid (H2SO4) (98%), digestion mixture tablet, sodium hydroxide (NaOH), boric acid (H3BO3), hydrochloric acid (HCl), alum (K2SO4), ammonia (NH3), and ethanol.

2.2 Wild Carob Powder (WCP Preparation

Approximately 100 g of wild carob were crushed, and the seeds were removed. The seedless crushed wild carob pods were roasted in an oven (Rational Selfcookingcenter, model 102, GERMANY) at 130 °C for 30 min. The roasted wild carob samples were placed on the trays of the conventional food grinder (PANA-MX-800) and ground for 1 minute at high speed. Finally, after grinding, the ground roasted wild carob sample was sieved using a conventional sieve with a particle size of 0.18 - 0.20 mm. The obtained wild carob powder (WCP) was kept in an air-tight container at a temperature of 4 °C prior to analyses.

2.3 Physicochemical Analyses of Wild Carob Powder (WCP)

The physicochemical composition of wild carob powder was investigated to determine its proximate values, milling yields, water activity (Aw), as well as colour analysis.

2.3.1 Milling Yields Analysis

The milling yield analysis was done to find the percentage of yield of the WCP after it had dried. It is based on two major factors including the weight of the WCP before drying and its weight after drying, using the following formula[17].

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

2.3.2 Water Activity

Approximately 5 g of WCP and cocoa powder were transferred in separate plates and their Aw was estimated at 25 ± 0.2 °C using RotronicHygroLab, HP23-AW-A Set, USA[18], [19].

2.3.3 Color Analysis

Approximately 8 g of WCP and cocoa powder were placed into a petri dish and colour analysis was performed using a Hunter colourimeter (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 colourimeter 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. Colour was measured in 3 arbitrary sections.

2.3.4 Proximate Analysis

The moisture, crude protein, crude fat, total ash, and crude fibre contents of each sample were determined using standard methods from the Association of Official Analytical Chemists [18]. The moisture content of each fresh sample was determined by heating 2 g of the sample to a constant weight in a crucible in an oven set to 105 °C. The dry matter was used to calculate the rest of the parameters. The Kjeldahl method was used to determine crude protein (percent total nitrogen x 6.25) using 2 g samples; crude fat was obtained by exhaustively extracting 5.0 g of each sample in a Soxhlet apparatus using petroleum ether (boiling point range 40 - 60 °C) as the extractant. The ash content of 10 g samples was determined by incineration at 550 °C for 5 h in a muffle furnace. 2 g of sample were digested with H2SO4 and NaOH, then incinerated in a muffle furnace at 550 °C for 5 hours to obtain crude fibre. The moisture content of each sample was determined by heating 2 g of each sample to a constant weight in a crucible in a 105 °C oven. Each analysis was performed three times. The carbohydrates were calculated by difference. The sum of moisture, fat, protein, and ash contents was subtracted from 100 as it was described by [20]. The energy values of the biscuits were calculated for protein, fat, and carbohydrates based on Atwater factors [21]:

Fat factor = 9.0 (Kcal/g).
Protein factor = 4.0(Kcal/g).
Carbohydrate factor = 4.0 (Kcal/g).
1 kcal = 4.184 (Kj).

2.3.5 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. Results and Discussion

3.1 Physical Characteristics of Wild Carob Powder (WCP)

Table 1 indicates the physical properties (i.e., color, water activity, and milling yields) of wild carob powder to cocoa powder (control sample).

Table 1: Physical properties of Wild Carob Powder (WCP) and Cocoa Powder**.**

Parameters	WCP	Control (Cocoa Powder)
Milling Yields (%)	27.39±0.11%^{b}	4±0.42%^{a}
Water Activity (a_w)	0.382+0.01^{a}	0.554+0.01^{b}
(L*)	41.38± 0.31^{a}	41.95±0.40^{a}
(a*)	9.90± 0.10^{a}	11.56±0.23^{b}
(b*)	13.75± 0.13^{a}	13.77±0.04^{a}

Notes: (L*) = lightness, (a*) =redness, and (b*) = yellowness of hunter color analysis
The 'a-b' indicates a significant difference ($p < 0.05$) between the samples.

3.1.1 Milling Yields

The result obtained from milling yields analysis of WCP was 27.39±0.11% which was 6.8 times significantly higher than cocoa powder (4±0.42%) (Table 1). In comparison, a study conducted by [22], reported that milling yield values of wheat, rye, hulled barley, triticale, and hulled oat samples were 64.7 0.42, 59.1 0.28, 63.0 0.47, 58.9 0.35, and 35.1 0.14, respectively.

Based on the result, the lower milling yields percentage of WCP is due to equipment utilized during the grinding process. The laboratory disc mill WZ-2 (Sadkiewicz Instruments, Poland) used by [22] facilitated the realization of finer flour particles as compared to the conventional food grinder (PANA-MX-800) used to grind the WCP. As a result, during the sieving process, larger WCP particles were present, leading to a lesser quantity of WCP particles being sieved, hence lowering the milling yield value. A study by [23], mentioned that the type of equipment used during the grinding process of a food product influenced its milling yield value and highlighted that the quality of the raw material (nutritional composition & physical structure), as well as parameters like temperature and time (drying & grinding), also influence the yield value.

However, the reason behind the low milling yields of cocoa powder as compared to WCP is that a large portion of cocoa fruit (90%) is pulp, and in chocolate production, only cocoa seeds are being used, amounting to only 10% of the cocoa fruit [24]. According to [25], only 28.6% of cocoa seeds could be used to produce cocoa powder, while the remaining portion contains cocoa butter, cocoa liquor, and its shell. Conversely, wild carob pod, which is equal to 90% of the carob fruit, was used for the production of WCP, hence the reason for the higher milling yields of WCP as compared to the control sample (cocoa powder).

3.1.2 Milling Yields

The level of water activity in food products is important in predicting the onset and severity of mold spoilage. According to [26], food products with high water content are prone to rapid deterioration as a result of biological and chemical modifications. The RotronicHygrolab is one of the scientific methods for determining the water activity of food products.

Table 1 compares the water activity of WCP to the conventional cocoa powder (control sample). Based on the analysis, the water activity value of the WCP (0.382+0.01 aw) was lower than that of cocoa powder (0.554+0.01 aw). The result shows 16.6 times lower aw WCP compared to the cocoa powder (control sample). The low value of WCP can be attributed to the high fiber content of the WCP, which was 93.9% higher than the control sample, as previously mentioned in table 1. The fiber was found to be able to absorb water from the surrounding, hence reducing the aw. The findings are supported by a study conducted by [27], who highlighted that adding xanthan gum (i.e., high in fiber) to rice muffin reduces the water activity of the muffin due to the water absorption capacities of the fibers in xanthan gum, resulting in less water availability. However, both samples (i.e., WCP and cocoa powder) had water activity values that were less than the threshold (aw 0.60) required for micro-organisms to proliferate and cause spoilage [28]. Finally, a study done by [29], found that roasted Bambara groundnut flour had a significantly ($p \leq 0.05$) lower water activity as compared to Bambara groundnut flour and fermented Bambara groundnut flour.

3.1.3 Color Analysis

Color is one of the most salient parameters that influence consumers' preferences (food choice). As presented in Table 1, WCP had a lightness (L*) value of 41.38± 0.31 while that of cocoa powder was 41.95±0.40, showcasing an insignificant difference ($p < 0.05$) to the control sample. The insignificant difference in the lightness value could be attributed to the roasting temperatures (120 ℃ -140 ℃) and roasting time (30 min) used for both the WCP and the control sample, which is supported by[30], stating that the lightness of food products tends to be alike when put under similar processing conditions. Hence, emphasizing the reason for the non-significantly lower L* value of the WCP and control sample.

In terms of redness (a*) value, WCP was 9.90± 0.10, and that of cocoa powder was 11.56±0.23. Results show that WCP was 14.36% lower ($p < 0.05$) than the control sample, showcasing a significant difference. This significantly higher a* value of the control in relation to WCP may be contributed by the Maillard and caramelization reactions which occurred during the roasting process since wild carob was roasted for 30 min at 130 ℃, and the control sample was roasted for 30 min at a temperature of 120 ℃ -140 ℃. Finally, the resultant yellowness (b*) value of WCP was 13.75±0.13, and that of the control sample was 13.77±0.04. The WCP was about 0.02% lower than the control sample, which indicated an insignificant difference ($p < 0.05$). All the resultant findings are in agreement with the study done by[31], who highlighted that increasing the roasting temperature and time increases the rates of Maillard and caramelization reactions.

3.2 Proximate Analysis of Wild Carob powder (WCP)

This section presents the results obtained from the proximate analysis performed on WCP and cocoa powder (control sample). The proximate analysis of WCP in comparison to the control sample is shown in Table 2.

Table 2: Proximate analysis of wild carob (*Ceratonia siliqua* L.) powder and Cocoa Powder.

Proximate analysis	WCP	Cocoa powder (control)
Moisture g/100 g	2.1 ± 0.37^{a}	6.56 ± 0.24^{b}
Ash g/100 g DW	3.42 ± 0.05^{a}	4.63 ± 0.03^{b}
Dietary Fiber g/100 g DW	43.1 ± 0.54^{b}	1.03 ± 0.73^{a}
Protein g/100 g DW	4.66 ± 0.78^{a}	24.3 ± 0.66^{b}
Crude Fat g/100 g DW	ND $(<0.1)^{a}$	14.5 ± 0.15^{b}
Carbohydrate g/100 g DW	46.7 ± 0.87^{a}	48.9 ± 0.75^{b}
Energy kcal/100 g DW	205 (1221.73 kJ)	426 (1783 kJ)

Notes: 'a-b' indicates a significantly different (p< 0.05) between the sample, the determinations on dry weight (DW) basis.

3.2.1 Moisture Content

Moisture content is a crucial aspect when dealing with food powders, as it is associated with increased cohesiveness due to the inter-particle liquid bridges. Controlling moisture content before and after the food grinding process is critical for food industries to achieve higher energy efficiency [32]. Furthermore, the moisture content of powder is extremely important for food safety because the higher the moisture content, the lower the number of dry solids in the powder[33]. Micro-organisms naturally present in powder begin to grow at high moisture levels and produce off-odor and taste, reducing the powder's shelf-life [33]. Results from Table 2 shows that moisture content was found to be significantly lower in WCP (2.1 ± 0.37) than in the control sample (6.56 ± 0.24). The 67.9% lower (p <0.05) moisture content in WCP indicates greater stability for microbial growth. The WCP's moisture content was also found to be significantly higher than a study by[34], where they revealed that the moisture content of organic carob powder (8.49 ± 0,78) was 75.2% higher than WCP. Similar research by [34], found that the moisture content of carob powder was 6.05 ± 0.06, which was 65.2% significantly higher than WCP. However, the production of carob powder is being subjected to several approaches with variations in drying time & temperature and, grinding size & sieving particle dimension. Hence, these variabilities have a high tendency of impacting moisture content [32], [35]. Finally, the international food standards stated that the moisture content of cocoa powder is less than 7%, suggesting its unsuitability for micro-organisms and bacterial growth. Nonetheless, the proposed WCP satisfies the safety standards for storage [36].

3.2.2 Ash

The amount of ash content in a particular raw product could be used as a determinant to ascertain the quality of that raw product. However, the amount of ash content in cocoa powder reveals not only the quality of the cocoa but useful characteristics of its origin, level of adulteration, and its inherent minerals[37]. According to Kenya bureau standards, the ash content of cocoa powder should not be more than 8% [38]. Based on Table 2, the proximate analysis of WCP and cocoa powder (control sample), the ash content was 3.42 ± 0.05 g/100 g DW, and 4.63 ± 0.03 g/100 g DW respectively, thereby satisfying the standard. A study done on carob powder by[39], reported that the ash content of cultivated carob powder collected from Aswan Governorate, Egypt was 2.48± 0.01 g/100 g DW which was7.6% lower than WCP (3.16 g/100 g DW), suggesting the quality of WCP. Also, a study on cultivated carob powder (collected from Alexandria city, Egypt) done by [40], found that the ash content of roasted cultivated carob powder was 2.48± 0.01 g/100 g DW, which was 27.4% lower than WCP, which also magnifies the quality of WCP. Nonetheless, the different results (ash content) of carob powder could be affected by the location of its cultivation and other factors such as mineral content of the soil, climate conditions, and variety of carob (cultivated and wild species). These influencing factors are supported by [41], [42], who highlighted that the nutritional compounds of carob products are impacted by the genetic profile, environmental conditions, and other cultivating factors. Hence, the 46.1% margin of ash content of WCP to the control sample could be due to the high mineral content of cocoa beans, especially in phosphorus, potassium, magnesium [43].

3.2.3 Dietary Fiber

As presented in Table 1, the WCP dietary fiber content is 97.6% (p < 0.05), significantly higher than the control sample. This may be contributed by the amount of dietary fiber found in the wild carob itself. According to [43], the dietary fiber content of carob is 72.3% higher than cocoa beans, hence, supporting the findings of this study. The fiber content obtained in this study is found to be higher than in previous research. A study on 17 different beans conducted by [44], mentioned that all variants of beans contained dietary fiber in the range of 17.98 - 33.76 g/100 g DW, which is lower than that of the WCP. Moreover, a study on cultivated carob traditional products done by[35], found that organic carob powder (cultivated) and carob powder (cultivated) contain 37.32 g/100 g DW, 30.35 g/100 g DW dietary fiber, respectively.

Fiber is essential in food technology due to its water-binding capacity, gel-forming potential, fat mimicking properties, thickening effects, and extension of shelf-life [11]. The dietary fibers' viscous and fibrous nature can control the release of glucose in the blood over time while also increasing the viscosity of the gastric fluids, assisting in the proper control and management of diabetes and obesity. As a result, food and pharmaceutical companies are now marketing ready-to-use fiber additives for powder enrichment and reinforcement programs[45]. Hence, the WCP, which is a less expensive and healthy source of fiber to the human diet, could be of immense benefit for obese and diabetic patients.

3.2.4 Protein Content

Table 1 shows that cocoa powder had a protein content of 24.3 ± 0.66 g/100 g DW, whereas the WCP had a protein content of 4.66 ± 0.78 g/100 g DW. The WCP had a protein value that was 80.8% lower than the control sample ($p < 0.05$). Higher protein content was also reported in a study on the nutritional and antioxidant potential of carob flour and evaluation of functional properties, done by[46], who stated that the protein content of carob flour was 5.90 ± 0.10 g/100 g DW which was 21% higher than that of the WCP. Another study on the proximate chemical composition of carob powder conducted by[39] highlighted that carob powder contains 6.34 g/100 g DW of protein which was 26.4% higher than that of the WCP. The lower protein content in the WCP as compared to the results of previous findings might be attributed to the variants of carob studied since most of the studies used cultivated carob. This result was supported by a study on amino acid and sugar contents of wild and cultivated carob done by [47], who reported that the protein content of wild carob (4.76 g/100 g DW) was significantly lower than cultivated carob but was 3.1% higher than the WCP. On the other hand, the reason behind the 31.4% less protein content of the WCP than the control sample might be attributed to a lower protein content of the raw carob pods (range of 2.0–7.6 g/100 g DW) than cocoa beans (range of 10.0–16.0 g/100 g DW) [43].

3.2.5 Crude Fat

According to studies, obesity rates are increasing because people are following a more energy-dense diet [48], [49]. High energy-dense products usually contain a high amount of fat because 1 g of fat contains 9 Kcal of energy [50]. Furthermore, epidemiological research suggested that a high-fat diet increases the development of obesity and that the amount of dietary fat consumed and the degree of obesity are directly related [14].

Based on Table 1, the fat content of WCP was Not Detected (i.e., less than 0.1 g/100 g DW), which was 14.5 times lower than the control sample. The reason behind the lower fat content of the WCP is that the carob pods are already extremely low in fat (range of 0.4 – 1.3 g/100 g) [43]. On the other hand, the higher fat content of cocoa powder can be affected by the pressing pressure and the time of the preparation of cocoa powder. The preparation of cocoa powder involved roasting, grinding, pressing to extract cocoa butter and liquor), milling, and sieving. Originally, cocoa beans contained a range of 36.8 – 57.0 g/100 g fats but lost most of their fat content in the pressing phase to 12.65 ± 0.15 g/100 g DW.

A study was done on carob powder done by[51], which mentioned that carob powder contains 0.74 g/100 g DW fat which was higher than that of WCP. Another study on carob flour done by [46] highlighted that the fat content of carob flour was 0.53 ± 0.05, which is higher than that of the WCP. The lower fat content of the WCP as compared to other studies' findings can be attributed to different roasting temperatures and time. According to a study done by [52], Lipids are oxidized at high temperatures (i.e., during carob roasting), resulting in their decomposition into secondary products, such as alcohols, aldehydes, ketones, carboxylic acids, and hydrocarbons. As a result, the material's lipid content may be reduced. These results are supported those found by[53], who conducted a study on carob powder and mentioned that the fat content of roasted carob powder at 100, 120, 150, and 180 °C were 1.3 ± 0.02, 0.86 ± 0.3, 0.83 ± 0.12, and 0.71 ± 0.11 g/100 g DW, respectively. In addition, in terms of fat content, all roasted carob powder samples of [53] were significantly lower than non-roasted carob powder (1.6 ± 0.03 g/100 g DW).

3.2.6 Carbohydrate

Carbohydrates make up a large portion of a person's daily diet and should account for 45 to 65% of total calories consumed per day[54]. Based on Table 1, the WCP contains 46.7 ± 0.87 g/100 g DW, which is 4.71% significantly lower than the carbohydrate level of the control sample (48.9 ± 0.75 g/100 g DW). These differences can be attributed to the formula used for the calculation of carbohydrate content, which was determined by adding the percentages of protein, moisture, fat, and ash and then subtracting this amount from 100%. A study on carob products done by [55], reported that carob powder contains 89.00 g/100 g DW of carbohydrate, which is 47% higher than that of the WCP. Another similar study done on carob flour conducted by[56], highlighted that carob flour contains 83.03 ± 0.11 g/100 g DW of carbohydrate, which is 43% higher than that of the WCP. These differences between WCP and the previous studies were most probably due to the higher total sugar content of cultivated carob than the WCP. This theory is supported by[8], who researched sugar profiles of cultivated and wild carob and noted that the pods of cultivated varieties contained total sugars 17.7% higher than the wild type of carob pods. Furthermore, research on compositional analysis of locally cultivated carob performed by [52], noted that the cultivated carobs (i.e., Tylliria, Sfax, and Aaronsoh) are as high as 90.69 ± 0.25, 89.57 ± 0.33, and 90.79 ± 0.51 g/100 g DW, respectively.

3.2.7 Energy

Table 1 displays the energy content of the WCP and the control sample. According to Table 2, the energy content of the WCP (205 Kcal g/100 g) was % significantly lower than the control sample (426 Kcal g/100 g). Based on the formula used for the calculation of energy content of samples[28], the WCP is significantly lower in energy content than the control sample due to the 14.5 times lower fat content of the WCP. The amount of energy is calculated using the formula that consists of multiplying proteins by 4, carbohydrates by 4, and fat by 9. Nonetheless, a single gram of fat gives around 9 Kcal of energy, which indicates the idea that high levels of energy are produced by a higher percentage of fat. A study done on carob products carried out by [35], highlighted that the energy content of cultivated carob powder was 305 Kcal, which is 48% higher than the WCP. Another study on cultivated carob, performed by[39], mentioned that the energy content of carob powder was 346.95 Kcal g/100 g which is 68.7% higher than the WCP. This might be the effect of high fat, and especially, the carbohydrate content of cultivated carob.

4. Conclusion

Cocoa is the major material used by chocolate industries, and it is high in fat content. This makes its resultant products energy-dense. Hence, uncontrolled consumption of such products leads to conditions such as obesity. Therefore, having an alternative product for the cocoa powder that is low in energy for chocolate preparation is salient to reduce the rate of obesity. This study investigated and compared the physical and chemical properties of WCP to cocoa powder (control sample). In terms of color analysis, the WCP manifested similar properties as the control sample, and for water activity, the WCP proffered a significantly better result than the control sample. Lastly, the milling yields of the control sample were lesser than the proposed WCP.

On the other hand, the WCP was significantly high in dietary fiber as compared to the control sample. Also, results from the proximate analysis showcased that the WCP was significantly lower in ash, moisture, protein, carbohydrates, fat, and energy contents relative to the control sample. Consequently, the high dietary fiber and low energy content that is inherent in the WCP makes it a suitable alternative to cocoa powder for chocolate industries to help remedy the quandary of obesity. In addition, the underutilization of wild carob makes it a cheaper alternative to cocoa for chocolate industries.

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