The Influence of the Couple Temperature/Duration of Roasting on the Quantity of Extracted Butter

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Abstract

Cocoa beans are mainly composed of cocoa butter (50-55% of the total mass) and have important socio-economic significance due to their physicochemical properties in the food processing, cosmetics, pharmaceutical and chemical industries. Roasting can affect the amount of butter extracted. The Central Composite Design (CCD) method was used to study the effect of coupling temperature/duration on the amount of butter extracted. A total of 13 couples were tested. The results showed that the roasting conditions significantly affected the amount of butter added. Optimum coupling temperature–duration of 125℃ / 57 minutes and 140℃ / 40 minutes, the extraction rate is about 25%. However, the cocoa butter obtained exhibits a wide variety in terms of texture, color and odor characteristics. The physical and chemical properties of the extracted butter have no effect on the roasting conditions. Both iodine and saponification indices are within the standard range.

Keywords

Cocoa beans; Roasting; Extracted cocoa butter.

Introduction

Cocoa beans consist mainly of cocoa butter (50–55% of total mass) which is of great socio-economic importance which is due to its physicochemical properties exploited in food processing, cosmetic, pharmaceutical and chemical industries (Jacquot et al., 2016; Lam et al., 2015).

Roasting is one of the important step to undergo in order to extract this healthy product as it affects its quality properties. During roasting, aroma and flavour properties such as alcohols, pyrizines, ethers, furans, esters, aldehydes and pyroles are developed at temperatures of 110–140℃ and time range of 20–50 min.

Extraction of cocoa butter is common in rural areas of cocoa production countries and it performance varies from one region to another due to poverty and lack of machine. Although traditional extraction methods are largely used, extraction yields are relatively low (10–20%) given that extraction yield depends on the degree of disruption of lipid-bearing cells (Zhen and Gao, 2017).

Several authors had conducted research on cocoa butter extraction based on various parameters such as particle size of cocoa nibs, utilization of various solvent, utilization of pressure (Morrison et al., 2015).

There is no study on the optimization of cocoa roasting based on the quantity of cocoa butter produced. This research aimed to study the best roasting conditions which could improve butter extraction yield using traditional extraction methods. For this study, flotation method of cocoa extraction is used because it is the most common in cocoa areas, compare to pressing method which is expensive (Krysiak, 2011; Zzaman et al., 2017). Therefore, this study was focused on the influence of couple temperature/duration on the quantity and the quality of butter obtained, using Central Composite Design (CCD) with two independent variable, temperature and time and one dependent variable, the quantity of butter as response.

Materials and Methods

Cocoa Beans

Cocoa beans (*Forastero amazonian*) were obtained from Bafia, Centre-North cocoa production basin of Cameroon. The desired cocoa beans were collected using a sieve. The samples were kept sealed in bags and stored at room temperature for further analysis.

Cocoa Roasting

Roasting was carried out as suggested by the Central Composite Design (CCD) using Design-Expert software version 6.0 (Stat Ease Software). Two independent variables were used: temperature (110–156°C) and time (10–57 min). The dependent variable (response) determined the quantity of the butter extracted. The cocoa beans were roasted in an oven (BINDER: Beiblatt-Anheben-08-06, art-Nr 7001-0123).

Butter Extraction by Flotation Method

Butter extraction was done according to Mounjouenpou et al. (2012). Roasted cocoa beans were de-shelled and milled to obtain the cake called cocoa liquor. Cocoa butter was obtained by flotation. The cake was submerged in boiling water (about 100°C) and the mixture was regularly turned to allow formation of oil droplet. After that, the floating oil droplets were collected carefully from the surface until exhaustion. Extraction was done from 500 g of roasted cocoa.

Physicochemical Analysis

(i) Saponification Index

The saponification index is obtained by colorimetric method according to French standard. This method consists of preparing the fat solution by dissolving fat in a mixed solvent (ethanol-diethyl ether), adding when heated a solution of alcoholic KOH, and assay the excess of KOH with a standard solution of hydro-chloric acid in the presence of phenolphthalein until colorless.

(ii) Iodine Index

The iodine index of butter samples was determined by the method of Wijs. This method consists of treating the fatty sample with an excess of Wijs reagent (iodine monochloride) which binds to the double bonds. The excess reagent is dosed with potassium iodide and the liberated iodine is assayed with sodium thiosulfate solution in the presence of starch paste.

(iii) Peroxyde Index

The peroxide index of butters was determined by Near-Infrared spectrometry, according to French standard. The principle of this method is based on the titration, with a solution of sodium thiosulfate N/200, of Iodine molecules released by oxidation of iodides by hydro-peroxides. The fat is first solubilized in a mixture of acetic acid and chloroform.

(iv) Free Fatty Acid

The Free Fatty Acid (FFA) of butter samples were determined according to Ocho (1999) method. To extract and neutralize all the FFA contained in butter samples, a 5 g sample of fat was dissolved in a solution of 0.01 N alcoholic NaOH in presence of phenolphthalein. The obtained hydro-alcoholic solution was acidified with 20 mL of a 1/3 sulfuric acid solution and the liberated fatty acids were extracted with 50 ml of hexane. The excess of hexane is subsequently evaporated and the free fatty acids are then converted to methyl esters by addition of a methanolic solution of sulfuric acid.

(v) Initial Fusion Point

The initial fusion point of the samples was determined by the methods described by Hamilton and Rossel (1986).

Sensorial Characterization of Cocoa Butter

Sensorial characteristics are defined according to the modified version of sensorial test as described by Konan et al. (2003), at the Food Technology Laboratory of the Institute of Agricultural Research for Development, IRAD Yaoundé, Cameroon. These analysis were done by 16 trained panelists (10women and 6 men). The average age of panelist was 33 years old for men and 27 years old for women. The sensory analysis was conducted at room temperature (about 25°C). The panelists were familiar with cocoa butter and were chosen for their sharp- ness of smell and capacity to distinguish colours. For each sample, and for the same panelist, four repetitions were done.

Texture was determined by smashing between the thumb and the forefinger the equivalent of 1 g of cocoa butter. The butter was said to be melting when it melted upon first friction and said to be compact on the contrary. Scores were attributed with respect to meltiness of butter: 1 = not, 2 = yes.

Colour of the butter was characterized by depositing a hazel of cocoa butter on a white sheet of paper. This feature was to evaluate how yellow-gold the butter was presented and scores allocated were: 1 = light, 2 = moderate and 3 = intense.

Odour was evaluated by smelling the aroma of the butter spread in between the fingers. The smell was said to be “intense” when the butter inhaled had the characteristic odour of roasted cocoa without friction. The odour was said to be “moderate” if the smell was sensed only after friction between fingers and ‘faint’ when only a poor aroma was perceived even after friction. A three-point score scale was used: 1 = poor, 2 = moderate and 3 = Intense.

Taste butter samples were heated at 40°C to make it liquid and panelist tasted them and scores were attributed with respect to their bitterness: 1 = bitter, 2 = not bitter.

Statistical Analysis

All analyses were done in triplicate. Test of normality was used to evaluate the distribution of data on the quantity of butter obtained. After that, the non-parametric Kruskall-Wallis Ranking test was used to analyze the effect of different couples of temperature – duration on the quantity of butter produced. Linear regression was also done to confirm the result which was illustrated by a boxplot. Statistical software used are Graph pad prism (ShapiroWilk, test of normality), R.3.3.1 (Kruskall-Wallis ranking test, linear regression and boxplot).

Results and Discussion

Quantity of Butter Extracted Base on the Emperature-Duration Couple Used

Twelve roasting conditions (couple temperature/duration) were assigned based on the Central Composite Design (CCD) results, with 5 central points with same couple temperature – duration (125°C/ 25 min). CCD for the quantity of butter obtained from the roasted cocoa beans is shown in Table 1.

According to roasting condition, the quantity of butter extracted from 500 g of roasted cocoa beans by traditional method ranged from 59 g to 125 g. Table 1 highlighted that the extraction yield increased with temperature and time. The best conditions of roasting (couple temperature/duration) observed were 125°C for 57 min, and 140°C for 40 min, with the highest butter quantity of 123.9 g and 125.0 g respectively. These values represented about 25% of roasted cocoa beans mass.

Roasting is an important operation which allows bursting of oleiferous cells in order to release oil. There are many different ways to roast cocoa beans; most of them depend on the type of derived product that is being made. Roasting conditions and extraction method significantly influenced the quantity of butter obtained. The results of this study indicated that high temperature – short duration and low temperature – long duration seemed to be the best roasting conditions of cocoa beans, and proved that the quantity of butter extracted was temperature and time dependent.

Table 1: Central Composite Design (CCD) for the quantity of butter obtained from roasted cocoa beans

Runs	Temperature (°C)	Duration (min)	Average quantity of butter (g)	Extraction yield (%)
1	110	10	75.1 ± 1.2	15.0
2	140	10	98.3 ± 0.9	19.6
3	110	40	98.3 ± 1.3	19.6
4	140	40	125.0 ± 2.7	25.0
5	125	25	73.3 ± 1.7	14.6
6	125	25	71.6 ± 1.8	14.3
7	156	25	109.5 ± 0.9	21.9
8	125	14	59.3 ± 1.8	11.9
9	125	57	123.9 ± 1.9	24.8
10	125	25	70.3 ± 1.6	14.1
11	125	25	69.3 ± 1.5	13.9
12	125	25	71.3 ± 0.9	14.3

±: Standard deviation.

The butter extraction yield obtained using traditional extraction method in this study (about 25%) was better than that of Adabe and Ngo-Samnick (2014) who obtained a maximum extraction rate of 15%, with cocoa bean roasting condition of 98–120°C for 90–95 min, and at 120°C, 130°C, 140°C, 150°C, 160°C, 170°C for 20, 30, 40, 50 min respectively. Similar results were obtained with other vegetal butter extracted using two traditional methods (15–28%). Comparatively to improved method, traditional method extraction performance was significantly lower than that of press extraction (46%) (Adabe and Ngo-Samnick, 2014), or chemical extraction (45.0–51.4%).

The Shapiro-Wilk normality test revealed that the quantity of butter extracted according to roasting condition was not normally distributed (p-value > 0.05). Therefore the Kruskall-Wallis ranking test was used to evaluate the effects of the different couples (temperature/duration) on the quantity of butter produced. This test highlighted that roasted condition (couple temperature/duration) significantly influenced the quantity of butter obtained (Figure 1). This result was also confirmed by a linear regression which attested these effects, with runs 4 and 9 roasting conditions, i.e. 140°C/40 min and 125°C/57 min, being the best.

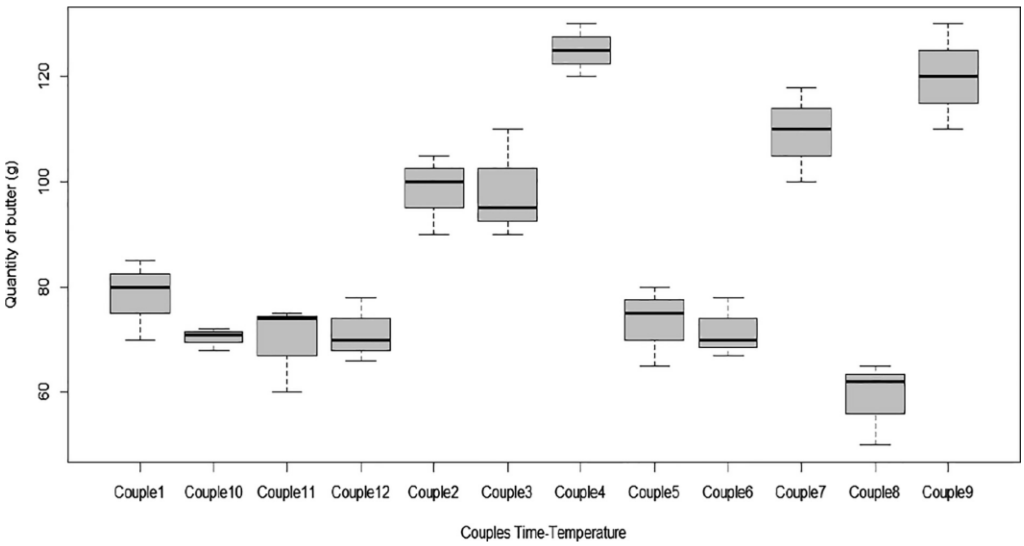

Figure 1: Effect of couples temperature/duration on the quantity of produced butter.

Sensorial Characterization of Extracted Cocoa Butter

Sensorial characterization of the cocoa butter obtained was done on only 8 samples (R1, R2, R3, R4, R5, R7, R8, and R9) because the experimental design plan gave five central point (R5, R6, R10, R11, R12) with the same couple temperature-duration (125°C/25 min).

The quantity of cocoa butter obtained in this study presented a wide diversity with respect to texture, colour, taste and odour.

Irrespective of the sample, taste and texture evaluations showed that all the extracted butters were not bitter and melted in contact with fingers.

Three levels of golden-yellow colour intensity were obtained (light, moderate and intense) with 37.5% light, 25% moderate and 37.5% intense golden-yellow colour.

Cocoa roasted aroma or odour was more intense at high temperature of roasting with samples R3, R4 R7 and R9, than that of R1, R2, R5, and R8 where temperatures were lower. Three groups of cocoa butters were obtained with respect to odour intensity (faint, moderate and intense) with a dominance of an intense odour (50%, representing R3, R4, R7 and R9), followed by moderate odour (R2 and R5) and faint odour (R1 and R8).

Roasting is an important operation for the development of sensorial properties of cocoa beans. Cocoa beans that are not roasted have a bitter, acidic, astringent, and nutty flavour. Several researchers had reported on the effect of cocoa beans roasting conditions on the formation of cocoa flavour compounds. Likewise, optimization of roasting condition in term of flavour compounds, formation of pyrazine and acrylamide had been studied. Sensorial properties are important parameters in cocoa classification. It is a result of a combination of 400–500 compounds including aldehydes, ethers, thiazoles, phenols, sulfur compounds, pyrazines, ketones, alcohols, furans and esters.

Findings of this study points out an important sensorial diversity of extracted cocoa butter that could be due to the diversity of extraction methods, notably variation in roasting conditions (temperature and roasting duration) of cocoa beans. This diversity in sensorial properties has also been obtained by several researchers on vegetable oils.

Flavour is the sum of perceptions resulting from stimulation of the sense ends that are grouped together at the entrance of the alimentary and respiratory tracks experimented several cocoa roasting conditions on the flavour component: and concluded that there is a linear correlation between roasting temperature and that of flavour compounds (pyrazine compound formation). Misnawi and Teguh (2010) highlighted that the formation and the concentration of pyrizines depend on temperature and duration of roasting conditions. Farah et al. (2012) also indicated that the concentration of pyrizines increased with temperature, from 110°C to 160°C but dramatically reduced when roasting time was increased. Cocoa flavour is better developed at high temperature. As temperature increase, there is more formation of diketopiperazines which when mixed with theobromine, will contribute to the cocoa taste.

Physicochemical Characterization of Extracted Cocoa Butter

The results of the main physicochemical properties of cocoa butter extracted from roasted cocoa beans using a Central Composite Design are summarized in Table 2.

The light golden-yellow butter (R1, R2, and R8) had iodine index ranging from 33 to 38 gI_2/100 g, peroxide index was ranged from 20.30 to 22.88 mEgO2/kg, higher saponification matters: saponification index from 178 to 196 mg KOH/g) and FFA from 1.81 to 1.97%. Light golden-yellow butters had humidity rate of 13%.

The moderate golden-yellow butter (R3, R5) had iodine index ranging from 40 to 42 g I_2/100 g, peroxide index of 18.13 to 19.28 mEgO2/ kg, saponification index of about 191 mg KOH/g, and FFA of 1.86%. Moderate golden-yellow butters had humidity rate of 13%.

As for the cocoa butter with an intense golden-yellow coloration (R4, R7 and R9), its iodine index was ranged from 35 to 41 gI2/100 g, peroxide index were ranged from 33.22 to 40.24 mEgO2/kg, saponification index ranged from 177 to 190 mg KOH/g, and FFA ranged from 1.85 to 1.99%. Intense golden-yellow butters had humidity rate of 14%.

Roasting conditions contributes to many physical and chemical changes that significantly alter their properties. Extracted cocoa butter samples presented an important variation in physicochemical properties. This could be explained by the diversity of roasting parameters used.

Table 2: Some physicochemical properties of cocoa butter samples

	Iodine index (gl/100 g)	Peroxide index (mEqO2/kg)	Saponification index (mgKOH/g)	Free fatty acid (%)	Fusion point (°C)	Humidity (%)
R1	36 ± 0.8	22.88 ± 2.2	196 ± 2.9	1.81 ± 0.2	31 ± 2.2	13 ± 0.7
R2	33 ± 2.2	20.30 ± 1.5	178 ± 2.2	1.97 ± 0.1	33 ± 1.8	15 ± 1.2
R3	40 ± 2.0	18.13 ± 1.3	191 ± 2.8	1.86 ± 0.0	32 ± 2.0	13 ± 0.8
R4	35 ± 1.9	33.22 ± 1.8	179 ± 2.1	1.99 ± 0.4	30 ± 2.3	14 ± 0.5
R5	42 ± 1.7	19.28 ± 1.7	191 ± 3.9	1.87 ± 0.1	32 ± 1.9	13 ± 1.1
R7	37 ± 2.3	40.24 ± 2.3	177 ± 1.7	1.90 ± 0.3	30 ± 1.6	14 ± 1.1
R8	38 ± 2.2	22.45 ± 1.8	195 ± 2.4	1.92 ± 0.2	34 ± 1.7	13 ± 0.5
R9	41 ± 2.1	38.32 ± 2.6	190 ± 2.0	1.85 ± 0.2	33 ± 2.4	14 ± 0.6

±: Standard deviation.

Iodine Value (IV) is a convenient indicator of the degree of hardness of cocoa butter. The Iodine values of the analyzed fats ranged from 33 to 42 gI_2/100 g. The lowest IV values were (29.4 and 31.9 g I_2/kg). These values were within limits laid down in the literature). Higher values of IV could be due to the presence of antioxidant pigments responsible for the yellow coloration of butter, and also indicated a higher content of unsaturated fatty acids including triacyclglycerols. These acids are responsible for most of its softness. The peroxide index of extracted butter samples were within the standards (inferior to 50 mEgO2/kg), Change in the peroxide value may be due to roasting conditions and the effects of antioxidant substances in the cocoa butter formed during heating. It may also be the consequence of uncontrolled conditions of drying and conservation. The relatively low obtained peroxide value of cocoa butter was the characteristics of fat extracted from raw cocoa beans. Tan and coworkers believe that the reasons for low values of can be found in the formation of hydroxyperoxides at lower temperatures. However, longer heating increases the temperature, which contributes to the rapid decomposition of the hydroxyperoxides to secondary, labile products, which can transform into products such as alcohols, aldehydes, ketones, acids, dimers, trimers, polymers and cyclic compounds.

The saponifiable fraction of butter samples was studied through saponification index and Free Fatty Acid. The obtained saponification indexes are within the limits of standards norms. FFA reflects the degradation of triglycerides. FFA levels of all butter samples were above the standard, i.e. above 1.75%. These findings were similar to that of Ivorian cocoa butter where important levels of FFA were also obtained on some cocoa producer areas. Indeed, FFA provide information's on the degradation rate of cocoa butter that can either result from an enzymatic activity, or result from the mishandling of postharvest treatments. An important FFA content would strongly affect the fundamental technological properties of butter, alter the solidification kinetic and soften considerably the cocoa butter. It also has an adverse effect on crystallization treatments such as tempering.

Samples of cocoa butter presented high levels of humidity (13–15%). The relatively high humidity rates could be linked to the use of water for its extraction, but also for their adulteration in post-preparation with water. Fats exposed to air could undergo hydrolysis and oxidation reactions under the combined effects of atmospheric germs (lipase and oxidase action), sun rays and atmospheric oxygen.

Conclusion

The Central Composite Design permitted the definition of 12 roasting conditions based on the couple temperature/duration. The cocoa butter was extracted traditionally from cocoa beans roasted according the above-mentioned conditions. According to the results obtained, extraction yield increased with temperature and time. The best conditions of roasting observed were 125°C for 57 min, and 140°C for 40 min, with the highest quantity of butter: 123.9 g and 125.0 g respectively. These values represented about 25% of cocoa beans. These roasting conditions permitted to obtain cocoa butter samples which varied with respect to texture, odour and colour. Iodine and saponification indices were within the norms or standards. However, the humidity rates of the studied cocoa butter were largely above the standard rates probably due to extraction in water.

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