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Temperature/duration couples variation of cocoa beans roasting on the quantity and quality properties of extracted cocoa butter

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ABSTRACT

Roasting is an important process that could influence the quantity of butter extracted. Central Composite Design (CCD) approach was used to study the influence of the couple temperature/duration of roasting on the quantity of extracted butter. The roasting conditions used were temperatures in the range of 110–197 °C and time ranging from 10 to 57 min. A total of 13 couple was tested. The result highlight that roasting conditions significantly affected the quantity of obtained butter. The best couple temperature – duration were 125 °C/57 min and 140 °C/40 min with an extraction yield of about 25%. However, obtained cocoa butter presented a wide diversity with respect to texture, colour and odour characteristic. Physicochemical properties of extracted butter were not function to the roasting conditions. Iodine and saponification indices were within the norms. However, the humidity rates of the studied cocoa butter were largely above the standard rates. Findings of this research are useful to food industries, and the impact of cocoa roasting on the extracted butter properties could help developed new products.

1. 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 (Kitamura et al., 2003; Maranz et al., 2004; Schreckenberg, 2004; Żyżelewicz et al., 2014).

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 (Hashim et al., 1998; Jinap et al., 1998; Misnawi and Teguh, 2010; Żyżelewicz et al., 2014) are developed at temperatures of 110–140 °C and time range of 20–50 min (Jinap et al., 1998).

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.

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 (Li and Hartland, 1992; McHugh and Krukonis, 1994; Rossi, 1996; Asep et al., 2008).

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. 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.

2. Materials and methods

2.1. Cocoa beans

Cocoa beans (*Forastero amazonian*) were obtained from Bafia,

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Table 1
Central composite design for two factors and level of independent variables.

Runs	Variable in coded unit		Variable in original unit	
			Temperature: °C	Duration: min
	X_1	X_2	X_1	X_2
1	−1	1	110	10
2	1	−1	+140	10
3	−1	1	110	40
4	1	1	140	40
5	0	0	125	25
6	0	0	125	25
7	−√2	0	156	25
8	0	−√2	125	14
9	0	+√2	125	57
10	0	0	125	25
11	0	0	125	25
12	0	0	125	25

X_1, X_2 = independents variables.

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.

2.2. Cocoa roasting

Roasting was carried out as suggested by the Central Composite Design (CCD) using Design-Expert software version 6.0 (Stat Ease Software) (Jinap et al., 1995; Montgomery, 2001). 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), according to variables showed in Table 1.

2.3. 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.

2.4. Physicochemical analysis

2.4.1. Saponification index

The saponification index is obtained by colorimetric method according to French standard (NF ISO 3657, 2013). 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 hydrochloric acid in the presence of phenolphthalein until colorless.

2.4.2. Iodine index

The iodine index of butter samples was determined by the method of Wijs (A.O.A.C, 1980). 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.

2.4.3. Peroxyde index

The peroxide index of butters was determined by Near-Infrared spectrometry, according to French standard (NF T 60-220, 1995). 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.

2.4.4. 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.

2.4.5. Initial fusion point

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

2.4.6. Humidity

Humidity of cocoa butter was determined according to the principle of dehydration by oven drying (80 °C) of samples (5 g) until attaining of a constant weight as described by A.O.A.C (1980).

2.5. 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 sharpness 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.

2.6. 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