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Physical properties and Sensory acceptability of dark chocolate from Allanblackia *floribunda* fat as substitute for cocoa butter

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Abstract
The study investigated the physical properties and sensory acceptability of dark chocolate prepared using Allanblackia floribunda fat as an alternative to cocoa butter (CB). Dark chocolate was made by full replacement (100%) of cocoa butter with Allanblackia floribunda fat while other ingredients were kept constant. Four physical properties including moisture content, melting point, hardness and particle size were evaluated by standard methods. Sensory attributes in terms of appearance, texture, flavor, taste, quick melting and overall acceptability were analyzed by hedonic rating scale. Assessors were mostly elderly persons. Results showed that moisture content and melting point varied between 0.42 and 0.85 % and 34 and 38 ℃ in chocolate made from Allanblackia floribunda fat and cocoa butter, respectively. There were significant difference ($p < 0.05$) in hardness (10.26 and 8.98 N/mm^2) of chocolate from
Allanblackia floribunda fat and cocoa butter, respectively. For sensory attributes; appearance, texture, flavor, taste and quick melting the data illustrates that the hedonic rates were between like moderately and like very much for chocolate from Allanblackia floribunda fat and the control after 60 days of storage. Overall acceptability of the sample and control after 60 day storage were like moderately and like slightly, respectively. Nevertheless, both samples were accepted. Chocolate from Allanblackia fat can withstand hot climates and will not melt in a warm shop due to its high solid fat content. Allanblackia fat is an unpopular and unexploited commodity in Nigeria. Findings from this study show that A. floribunda fat can be a suitable substitute for cocoa butter in dark chocolate production.

Keyword: *Allanblackia floribunda fat, cocoa butter, physical properties, Sensory attributes*

Introduction

Chocolate is a product made from cocoa (*Theobroma cacao* L.) bean derivatives in combination of other ingredients ((Urbańska and Kowalska, 2019). Chocolate is high in antioxidant content with health benefits that can reduce the risk of heart disease and help brain function among others (Abdul Halim, Selamat, Mirhosseini, Hussain, 2019). Based on ingredient composition Chocolate bars are categorized into three types; dark chocolate, milk chocolate and white chocolate (Sim, Ng, Forde, Henry, 2016). Dark chocolate is a chocolate that does not contain milk solids; it differs from milk chocolate due to its high polyphenols content. According to Urbańska and Kowalska,

(2019), polyphenols have antioxidant properties that effect sensorial qualities, such as taste and color, dark chocolate is said to be more beneficial in terms of human health (Żyżelewicz et al., 2018).

Cocoa butter (CB) is one of the most important ingredients in chocolate because of its physicochemical properties and low melting point range (33˚C − 35˚C) with maximum coldness in the mouth (Ornla-ied et al., 2022, Biswas et al., 2016).Cocoa butter represents the continuous phase and help in the dispersion of the other ingredients; milk, sugar solids etc. Cocoa butter is also associated to the quality in the final product, being responsible for the characteristics of hardness, snap; thorough melting in the mouth, contraction during demolding and chocolate shine and product stability to fat bloom (Suri & Basu, 2022). Cocoa butter is largely composed of three triglycerides: palmitic oleic palmitic (POP), palmitic oleic stearic (POSt) and stearic oleic stearic (StOSt) (Moreno, Torrescana, Salvado and Blanch, 2015).

Allanblackia fat is an edible vegetable fat derived from the seeds of Allanblackia trees. The fat is composed of few triglycerides, derived from palmitic, oleic, and stearic acids. Precisely Allanblackia fat contains 52-58% stearic acid, 39-45% oleic acid and 2-3% palmitic acid. This is similar to other tropical fats like shea and cocoa butter. Allanblackia fat melting point is around 34 °C. The melting behavior is provided by the triglyceride composition (Lovett, 2014). Allanblackia fat does not need modification like fractionation or refining before it can be used for making food products such as a structuring fat to produce low-trans margarines and dairy cream alternatives (European Commission (2014). This melting point of cocoa butter makes it a unique component in chocolate making; however, in the tropics this melting point can be a problem as chocolate can melt before reaching the consumer. In order to cope with such problem, partial/full replacement of cocoa butter with Allanblackia fat is recommended.

Sensory characteristics of chocolate are critical to consumer's appreciation of its product. Critical senses used in assessing chocolate qualities include; Sight, Touch Smell and Taste. In terms of senses of sight, the two characteristics of chocolate are its color and gloss. Chocolate without sheen or bloomed, is unlikely to be purchased. Vision can also affect taste (Nedomová, Gregor, 2021). Touch is related to how a chocolate breaks and also its behavior in the mouth. This includes the snap of a chocolate bar as well as whether it melts away smoothly or is harder to swallow. The texture of chocolate is unique being solid and able to be snapped at ambient temperatures, yet melting smoothly in the mouth. This is largely due to the melting properties resulting from composition of the fat used and also affected by processing. The smell/aroma of chocolate is very attractive to most people, but if it is contaminated by burnt odors or chemical taints the product can become totally unpalatable. Taste is the most important sensorial quality. The cocoa, milky, sweet, acidic etc., flavors combine to give a unique tasting experience (Medina-Mendoza, Rodriguez-Pérez, Rojas-Ocampo, Torrejón-Valqui, Fernández-Jeri, Idrogo-Vásquez, et al. 2021). Chocolate lovers sometimes referred to as ''chocoholics'' needs the sensory experience of the real product with cocoa butter. Hence, this paper was aimed at evaluating the physical properties and sensory acceptability of dark chocolate from Allanblackia *floribunda* fat as substitute for cocoa butter.

Materials and methods

Chocolate preparation

One dark chocolate recipe with Allanblackia fat was formulated while the composition of the control sample purchased from a local supermarket in Port Harcourt was taken from the package label (Table 1). The dark chocolate was formulated with 36% Allanblackia fat, 28% date syrup; 35.5% cocoa powder and 0.01% of vanillin flavour. The mixture of ingredients (date syrup and cocoa powder) was performed for a period of 15 min. After the mixture, the dry conching process (65 ℃ for 5 h) was carried out. For the liquid conching, the Allanblackia fat was added. After 1 h of the liquid conching vanillin were added. The mass refining process was made in batch using a mill balls with a grinding chamber with a capacity of 1 L. A digital micrometer Mitutoyo 293, (Suzano, Brazil) was used to monitor the reduction of the particle size in order to obtain particles with a maximum size of 25μm. For the tempering process the chocolate (1 kg), was cooled from 45 to 28 C using a cooling rate of 2.0 C/min on a granite table. Then the chocolate was shaped into rectangular mold, crystallized in a refrigerator (8 ℃/45 min.), demolded manually, and packaged.

Table 1 Dark chocolate formulation

Ingredient	AFC	CBC
Fat (%)	36	36
Cocoa powder (%)	35.5	35.5
Soy lecithin (%)	-	0.3
Date syrup (%)	28	-
Sugar (%)	-	27.9
Vanillin (%)	0.01	0.01

AFC = chocolate from Allanblackia fat, CBC = chocolate from cocoa butter

Physical properties of *A. floribunda* and cocoa butter (CB)

Analytical Methods

Melting point

A two hundred and fifty (250 ml) milliliter beaker was placed inside a water bath. Water was poured into glass and water bath and conditioned to the same height. The initial temperature of water inside the beaker glass and water bath was set to be 27℃, measured using a thermocouple. Afterwards, 1 cm x 1 cm x 1 cm chocolate was put in a concave spoon and placed inside beaker glass, submerge into the water. The sample was slowly stirred and temperature of water bath was increased by 1℃ in 1 min of interval. Chocolate melting point was indicated by the change of chocolate formation inside the spoon which becomes softer and melts easily.

Moisture content

Moisture content of the dark chocolate was determined using halogen moisture analyzer (Mettler-Toledo GmbH, HX204, Switzerland) as described by Elbl et al. (2020) method, with some differences. One (1 g) gram of each sample was accurately weighed in a crucible and placed in the analyzer, then, heated to 105°C until a constant weight was reached. The value displayed at the end of the determination was recorded as moisture content.

Hardness

Chocolate hardness was measured using Brookfield texture analyzer at a room temperature of 27℃. A needle probe was applied (TA39, diameter 2 mm) to the instrument and samples were penetrated to a depth of 3 mm with a constant speed of 0.5 mm/s [28]. All measurements were

done in duplicate. The chocolate samples were stored for 60 days. Hardness value was calculated using Equation

$$\sigma = \frac{\text{load} \times \alpha}{\pi \times r\,2}$$

Where σ defines the hardness (N/mm^2), load is the maximum load (kg), α is gravitational acceleration (m/s^2), r is needle probe radius (mm).

Sensory evaluation of dark chocolate

Sensory attributes of the dark chocolate—containing *Allanblackia floribunda* fat and cocoa butter were studied. The sensory test was conducted immediately after processing (day 0), and then after the storage of 15, 30 and 60 days at the room temperature using the scoring procedure. The basic sensory properties studied were appearance; flavour; taste; texture and overall acceptability using a nine point hedonic scale (i.e., 1—dislike extremely; 2—dislike very much; 3—dislike moderately; 4—dislike slightly; 5—neither like nor dislike; 6—like slightly; 7—like moderately; 8—like very much; 9—like extremely). The results obtained were statistically analyzed. All tasting sessions were carried out in the same conditions, following the same procedure, in the same place and at the same time of day. Tasting area was in a quiet room with comfortable chair to sit and a clean table surface. Room temperature was between 20-22°C. Lighting was adequate and the area free from strong odours and distractions, walls was with neutral colours. There was no strong scent, perfumes, lotions, deodorants or aftershaves unless these are odourless. Hands were washed prior to tasting with perfume-free soap. Smoking, drinking alcohol, coffee or eating food within 60 min prior to a tasting session was not allowed. Persons suffering from colds or any illness affecting senses of smell and taste were refused tasting until fully recovered. Before tasting, cold water drinking by panelist was avoided. All chocolate stored in a cold room were brought out of storage 1 h before the tasting to room temperature. Between samples: mouth was rinsed to avoid saturation and carry-over effect of flavours from one sample to another. Short break was permitted to allow the palate and taste buds to recover. Finally, a sensory evaluation form was presented to panelist.

Statistical Analysis

Data obtained were reported as mean ± standard deviation. Minitab Software version 19 (Minitab LLC., State College, PA, USA) was used for the statistical data analysis. From each chocolate batch, three independent samples (n=3) were extracted for their respective analysis. One-way ANOVA and Tukey's range test were used to evaluate the significant differences among each treatment. Statistical significance tests were performed at P = 0.05.

Results

Table 2: Physical properties of *A. floribunda* and cocoa butter (CB)

Parameter	Chocolate from *A. floribunda*	Chocolate from cocoa butter
Moisture content (%)	0.42^{b}±0.11	0.85^{a}±0.10
Melting point (°C)	36^{b}±0.20	38^{a}±0.15
Hardness (N/mm^2)	10.26^{a} ±0.14	8.98^{b}±0.04

Values are means ±standard deviation of duplicate determination. Means that do not share a letter are significantly different (P<0.05).

Table 3: Sensory evaluation of dark chocolate from *A. floribunda* and cocoa butter (CB)

Chocolate sample	Storage days	Appearance	Texture	Flavor	Taste	Quick melting	Overall acceptability
AFC	0	7.4^{d} ±0.00	6.5^{d}±0.10	8.2^{a}±0.00	7.5^{a}±0.20	$9.0^{\mathbf{a}}$±0.14	$7.72^{\mathbf{a}}$±0.12
	15	7.6^{c} ±0.07	7.2^{c}±0.07	7.8^{b}±0.10	7.2^{ab}±0.04	$8.5^{\mathbf{b}}$±0.16	$7.66^{\mathbf{a}}$±0.14
	30	7.8^{b} ±0.11	7.5^{b}±0.07	7.5^{bc}±0.02	$7.0^{\mathbf{bc}}$±0.03	$8.3^{\mathbf{bc}}$±0.11	$7.62^{\mathbf{ab}}$±0.15
	60	8.2^{a} ±0.14	7.8^{a}±0.02	7.2^{d}±0.11	$6.5^{\mathbf{d}}$±0.07	$8.2^{\mathbf{c}}$±0.12	$7.58^{\mathbf{c}}$±0.16
CBC	0	7.0 ±0.04	6.1^{e}±0.04	8.0^{a}±0.22	$7.5^{\mathbf{a}}$±0.11	$8.6^{\mathbf{b}}$±0.00	$7.44^{\mathbf{d}}$±0.07
	15	7.2^{e} ±0.10	6.5^{d}±0.20	7.5^{bc}±0.12	$7.2^{\mathbf{ab}}$±0.33	$8.5^{\mathbf{b}}$±0.14	$7.38^{\mathbf{d}}$±0.12
	30	7.5^{cd} ±0.21	6.8^{d}±0.40	7.2^{d}±0.08	$7.1^{\mathbf{b}}$±0.02	$8.0^{\mathbf{c}}$±0.10	$7.32^{\mathbf{d}}$±0.11
	60	7.6^{c}±0.12	7.1^{c}±0.00	6.5^{e}±0.03	$6.4^{\mathbf{d}}$±0.14	7.1^{d}±0.11	$6.94^{\mathbf{e}}$±0.10

Values are means ±standard deviation of duplicate determination. Means that do not share a letter are significantly different (P<0.05), AFC = A. *floribunda* chocolate, CBC = Cocoa butter chocolate

Discussions

The use of Allanblackia fat in the production of dark chocolate significantly (p< 0.05) influenced chocolate moisture, hardness and melting point, (Table 2)

Melting point

The values determined for the chocolate from *A. floribunda* and cocoa butter (CB) are within same temperature range, and both values were very close (Table 2). Overall, chocolates melting temperature both sample were above 34℃. Agreeing to Stortz & Marangoni (2011) chocolate melting point higher than 33, 8℃ can be categorized as heat resistant chocolate. Melting point is one crucial parameter that indicates chocolate quality. Cocoa butter-based chocolate showed a higher melting point (38℃).

Moisture

Moisture in the chocolate with different types of fat did not show a significant difference (p >0.05) (Table 2). The result obtained was below the maximum moisture content allowed in chocolate products (< 2%). Moisture content is a parameter that has direct correlation with chocolate melting point, hardness, flow ability and appearance. According to Afoakwa (2010), chocolate with a moisture content of 0.5-1.5% does not affect the flow properties of chocolate. Good chocolate moisture content should be lower than 2%. Moisture content of more than 2% reduces the quality of chocolate due to the formation of sugar bloom. Similarly, excessive moisture in the chocolates can cause agglomeration of particles, affecting their thickness and flow behavior (Saputro et al., 2017; Ibrahim et al., 2020). In this study, all chocolates contained moisture content lower than 2%.

Hardness

Hardness is quality parameters of chocolate texture, Chocolate hardness is influenced by fat content, moisture content, particle size and tempering process as explained by Afoakwa, (2010). There was statistical (p<0.05) differences in chocolate hardness from Allanblackia fat (14.26 N/mm^2), differing from that of the reference sample (12.98 N/mm^2). Incorporating Allanblackia fat affected the chocolate hardness. The type of fat use in chocolate significantly affects its hardness, chocolate with low solid fat content tend to be softer than those with high solid fat

content; solid fat content (SFC) of cocoa butter range from 30-65% over the temperature range 10–30 ℃ (Ostrowska-Ligeza E., Marzec A., Gorska A., Wirkowska-Wojdyla, Brys, Rejch, Czarkowska, 2019), this is lower than SFC observed in Allanblackia fat having higher value that ranged from 40-76% within temperature range 30–40 ℃. Different fatty acid compositions of various fats influence the melting point and crystal structure, directly impacting the chocolate's texture

Sensory acceptability

The results of the sensory acceptance tests are depicted in Table. 3. Hedonic acceptance of dark chocolates for chocolate from *A. floribunda* fat and a chocolate from cocoa butter from day 0, 15, 30 and 60 showed hedonic rates between like moderately and like very much for chocolate from *Allanblackia floribunda* fat and the control after 60 days of storage. Overall acceptability of the sample and control after 60 day storage were like moderately and like slightly, respectively. Nevertheless, both samples were accepted. Acceptance of food is directly related to the interaction of food with consumers at a certain time. Sensory characteristics such as taste, aroma, texture, and appearance of food affect the making of consumers' choice regarding the preference of food materials. Once the product consumed by consumers, they can conclude and decide whether they like or dislike the product.

Conclusion

A modification of the recipe, using Allanblackia floribunda fat steered to prototypes of the commercial chocolate product with 100% cocoa butter that seem to meet most of physical and sensory requirements. The sensory acceptability of the formulated dark chocolate was high. The chocolate showed good sensory characteristics comparable to the reference sample. Allanblackia fat is therefore recommended as substitute for cocoa butter.

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