Research Article
Cocoa Butter Color Development during Processing

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Abstract: Color parameters were measured using a CM-2002 Minolta Spectrocolorimeter. Lightness varied from its lowest value of 77.68 to its highest value of 79.60 with coefficients of variation less than 1%. Lightness was statistically ($p<0.05$) the same for filtration and clarification; and for drying and deodorization. There was no significant difference in greenness from filtration through drying, although the highest greenness ($a = -1.18$) was obtained after deodorization. Yellowness was statistically equal at filtration ($b = 31.34$) and clarification ($b = 31.19$); at washing ($b = 33.08$) and drying ($b = 33.02$). Results showed that the spectrocolorimeter was consistent and the step of washing yielded the lightest cocoa butter.

Keywords: Cocoa, cocoa beans, cocoa butter, color

INTRODUCTION

Cocoa butter is one of the most important and popular cocoa product (Pires *et al*., 1998). Its use in chocolate and other foods has been well documented. Gonze *et al*. (1997) studied the use of cocoa butter in chocolate although sucrose was replaced by sweeteners such as sorbitol and maltol which are low calories compounds. Simoneau and German (1996) have shown the contribution to the physical properties of cocoa butter's triglycerides in milk fat fractions. The use of cocoa products in chocolate and in number of chocolate based confections has been extensively discussed (Padilla *et al*., 2000; Ali *et al*., 1998).

Côte d'Ivoire, in western Africa, has been for many years, the world first producer of cocoa (*Theobroma cacao L*.) (Hokana, 1995; Losch, 1994). In order to improve its economy primarily based upon agricultural products such as cocoa, cotton and coffee, the country has allowed international firms like "La Société Africaine de Cacao" (SACO) to process cocoa beans into finished and semi finished cocoa products such as cocoa butter prior to exportation.

Color in many food products including cocoa butter, is of great importance (Cole *et al*., 1991). A recent investigation reported that the color of cocoa butter was based upon the only pigments such as carotenoids (Oliviero *et al*., 2009). Therefore, color appears as a key aspect in unprocessed and manufactured foods and an attribute for texture and flavor in regard with acceptance for consumers. Several systems for color appreciation exist and the most important one is the International Commission on Illumination. Though, one of the system often used in food is the Hunter L, a, b system. No and Storrebakken (1991) have reported that color is affected by many factors and can be measured through the following parameters of the Hunter L, a, b system. These parameters are the degrees of lightness (L), redness (+a), greenness (-a), yellowness (b) and blueness (-b).

Despite the large number of studies already carried out on cocoa and its related products, a lack of information on the development of coca butter's color during the steps of processing still remains. It is unclear which of the steps of the cocoa beans' processing best contribute to the color of cocoa butter. Therefore, this research was undertaken in an attempt to apply a spectrocolorimeter to follow the development of cocoa butter's color over the five major stages of the processing which are filtration, clarification, washing, drying and deodorization.

MATERIALS AND METHODS

Material: A CM-2002 Minolta spectrocolorimeter (Minolta Corp., Ramsey, NJ) was used to measure the color at different stages of the processing by measuring the Hunter L, a and b values. These parameters were analyzed at the solid state of the cocoa butter. The

spectrocolorimeter was used with the following reading and operating conditions:

Lightness: D 65
Geometry measurement: d/s
Standard Observer CIE: 10° - SCI
Measurement on a surface of 8 mm
The mean of three values is recorded
Colorimeter system: L, a and b
Citric acid (95%) was commercially obtained (Polychimie, Abidjan) and used to prepare 1M solution

Methods:

Processing steps: Cocoa beans fermented with microorganisms over an average period of 7 days were commercially obtained. Beans were naturally fermented with wild micro flora throughout cocoa plantations across the country. The fermentation was carried out inside holes dug on the ground. Holes were dug on the ground in a tilted manner in order to easily collect the sweating cocoa liquid during the fermentation process (Buamah *et al.*, 1997). After digging the hole, its bottom and sides were covered with large banana leaves. Then holes were filled with about one hundred kilograms of cocoa beans. Holes filled with beans were covered with other banana leaves. The fermentation was carried out over 7 to 9 days. Beans of each hole were moved to a new hole after 2 days of fermentation. Following fermentation, the beans were removed and sun dried on cemented flat surfaces. Then the fermented and dried beans were sold to cocoa processing plants such as SACO. Beans were then roasted and processed according to the scheme shown in Fig. 1. After grinding, drying and alkalinizing the cocoa seed, the liquid cocoa butter was partially defatted and passed through a two press filter system to remove particles. Then, the filtrated liquid cocoa butter was centrifuged at 6000 Revolutions/Min (RPM) to exclude fine particles. Upon centrifugation, the clarified butter was washed with the 1M citric acid solution and hot water (80 to 90°C) to get rid of soaps and other water soluble impurities. The washed butter was dried by heating at 100°C and deodorized at 179°C. During deodorization, the butter was heated inside a bottle-like container and filtered to remove heat induced particles. Then, the

Table 1: Repeatability of the CM-2002 minolta spectrocolorimeter in measuring the degrees of lightness (L), greenness (-a) and yellowness (b) of the cocoa butter obtained after the five steps of the processing

	Color		
	Lightness (L)	Greenness (-a)	Yellowness (b)
R_1	78.29	-0.97	34.07
R_2	78.26	-0.98	33.85
R_3	78.39	-0.98	33.31
R_4	78.76	-1.09	32.65
R_5	78.45	-1.03	32.46
Mean	78.43	-1.03	33.27
S.D.	0.21	0.08	0.71
C.V.	0.26	7.92	2.13

S.D.: Standard deviation; C.V.: Coefficient of variation; R_1 through R_5 represent the five replicates; $p < 0.05$

Table 2: Measurements at five surface sites of the degrees of lightness (L), greenness (-a), and yellowness (b) of cocoa butter obtained after the five steps of the processing

	Color		
	Lightness (L)	Redness (-a)	Yellowness (b)
	75.70	0.70	37.39
S_2	75.51	0.71	37.28
S_3	75.56	0.76	37.55
S_4	75.36	0.78	37.18
S_5	75.36	0.69	37.38
Mean	75.49	0.72	37.35
S.D.	0.14	0.04	0.14
C.V.	0.18	5.55	0.37

S.D.: Standard deviation; C.V.: Coefficient of variation; S_1 through S_5 represent the five measurements at the five different sites; $p < 0.05$

deodorized butter was cooled down and filtered to remove any remaining impurities. The color parameters were measured at each stage of the processing as previously described.

Sample preparation: At each of the five processing steps, 30 mL of the liquid cocoa butter were withdrawn and poured into a 50 mL beaker and the beaker was placed in a cold room at 6 to 7°C for 10 to 15 min. As the butter started to solidify, the liquid and solid phases were thoroughly mixed and transferred onto a tray. The tray was again placed in the cold room for 15 to 20 min. Then, the tray was removed from the room and the butter was taken off the tray and the color factors (L, a and b) were rapidly measured on the surface. Five measurements were performed per sample at each stage of the processing and the data are presented through Table 1 to 3.

Table 3: Variation of degrees of lightness (L), greenness (-a), and yellowness (b) of the cocoa butter over the five steps of the processing

Color	Processing				
	Filtration*	Clarification*	Washing*	Drying*	Deodorization*
Lightness (L)	77.28[a]	77.68[a]	79.60[b]	78.89[c]	78.50[c]
	S.D. = 0.61	S.D. = 0.35	S.D. = 0.44	S.D. = 0.58	S.D. = 0.76
	C.V. = 0.78	C.V. = 0.45	C.V. = 0.55	C.V. = 0.73	C.V. = 0.96
Greenness (-a)	-0.12[a]	-0.29[a]	-0.23[a]	-0.23[a]	-1.18[b]
	S.D. = 0.38	S.D. = 0.31	S.D. = 0.28	S.D. = 0.28	S.D. = 0.19
	C.V. = 16.60	C.V. = 106.80	C.V. = 21.70	C.V. = 121.7	C.V. = 16.10
Yellowness (b)	31.34[a]	31.19[a]	33.08[b]	33.02[b]	27.58[c]
	S.D. = 1.52	S.D. = 1.33	S.D. = 0.92	S.D. = 0.89	S.D. = 0.78
	C.V. = 4.85	C.V. = 4.26	C.V. = 2.78	C.V. = 2.69	C.V. = 2.75

*: All values are the means of five replicates; [a-c]: Means within the same row of the same attribute, with different letter, are significantly different ($p < 0.05$); S.D.: Standard deviation; C.V.: Coefficient of variation
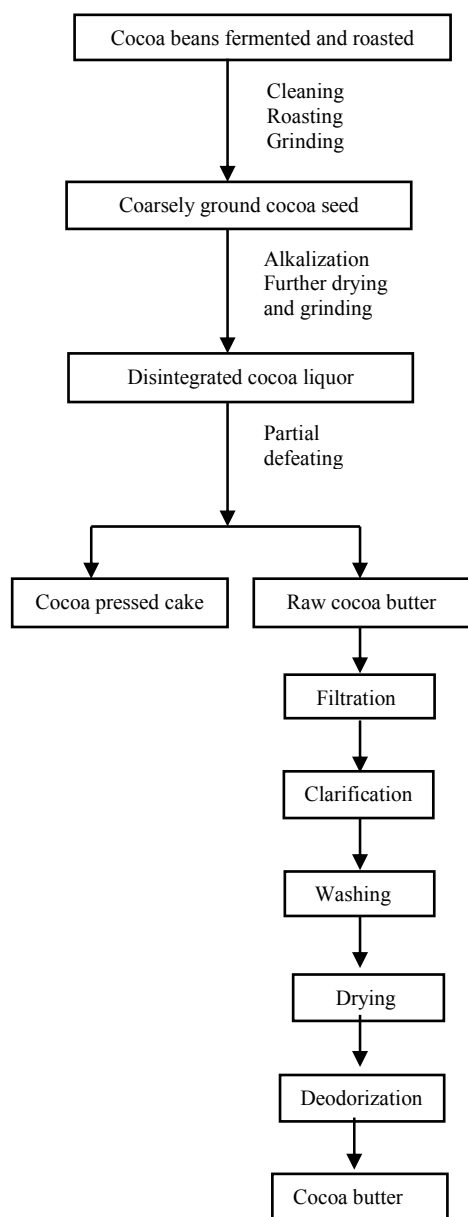
Fig. 1: Processing of fermented and roasted cocoa beans to produce cocoa butter

A statistical design consisting of the ANOVA and Fisher's Least Significant Difference (LSD) of the Statistical Analysis System (SAS Institute, Inc., 1985) was applied to show any color change during the development of the color over the different steps of the processing. Statistical significance was indicated for $p < 0.05$.

RESULTS AND DISCUSSION

The processing of the cocoa beans to produce the different cocoa products including cocoa butter is outlined in Fig. 1. Raw cocoa butter obtained after

extraction of part of the fats was further treated to yield the finished yellowish cocoa butter with a slight orange appearance.

Table 1 shows the repeatability of the CM-2002 Minolta spectrocolorimeter in measuring the color parameters. The ''L'' values varied from 78.26 to 78.76 with a mean of 78.43 and a coefficient of variation of 0.26%. As far as the ''a'' values are concerned, they varied from -1.09 to -0.97 with a mean of -1.03 and a CV of 7.92%. The values of the degree of yellowness (''b'') varied from 32.46 to 34.07 with a mean of 33.27 and a CV of 2.13%. Overall, the CV for the three color parameters were less than 5% for lightness and yellowness and less than 10% for the degree of greenness. The colorimeter therefore, was consistent in measuring the three color parameters and no significant difference was observed in lightness, greenness and yellowness for each series of five replicates.

Table 2 shows the effect of the surface on the values of lightness, redness and yellowness. Lightness varied from 75.36 to 75.70 with a mean of 75.49 and a CV of 0.18%. Redness varied from 0.69 to 0.78 with a mean of 0.72 and a CV of 5.55%. The third parameter which is yellowness varied from 37.18 to 37.55 with a mean of 37.35 and a CV of 0.37%. Lightness and yellowness had CVs less than 1% while redness had a CV of 5.55%. These results reveal that there was no significant difference in the values of each parameter measured at five different sites on the surface of the butter. As a result, the surface had no effect on lightness, redness and yellowness. Overall, surface had no significant effect on the color measurement of the butter. In the results of Table 1 we observed that the mean of lightness (L = 78.43) was significantly much higher than that (L = 75.49) shown in Table 2. However, yellowness had a lower intensity in Table 1 (b = 33.27) than in Table 2 (b = 37.35) and the cocoa butter was green in Table 1 and red in Table 2. It appears that the cocoa beans processed to obtain the butter in Table 1 were different from those manufactured to yield the butter of Table 2.

Table 3 displays the color variations of the cocoa butter during processing.

These variations are expressed by the degrees of lightness (L), greenness (-a) and yellowness (b). The ''L'' value rises from 77.28 to its highest value of 79.60 which is reached during the step of washing as all impurities are removed and the color is then clearly displayed. During the step of filtration, particles and impurities coming from the beans are removed. Then the filtrated butter is centrifuged in an attempt to remove any remaining fine particles. Then the butter is first of all mixed with the 1M citric acid solution and washed with hot water. Over these first three processing steps, most free fatty acids or saponifiable fats are removed and we obtain the lightest cocoa butter. After washing with hot water, carotenoids, the pigments responsible for the well appeared color of cocoa butter

are slightly altered during the subsequent steps of drying and deodorization. These steps involve heat treatment and therefore lead to the degradation of the color pigment. During drying, the remaining water is eliminated by evaporation at 100°C and the deodorization is achieved by heating the butter to 179°C. The ''L'' value significantly dropped from 79.60 to 78.50 and the brightness was proportionally reduced. All these thermal operations induced degradation of the color pigments, leading to a significant degradation of the carotenoids (Oliviero *et al*., 2009; Vissotto *et al*., 2010). Carotenoids are tetraterpens with eight 8 isoprene units with trans bonds. These compounds are mainly xanthophylls along with low quantities of β-carotene (Vissotto *et al*., 2010). Upon heating, these double bonds will isomerize to form double bonds in the cis form, leading to the loss of the color intensity. Finally, there was no significant difference in lightness during filtration and clarification and between drying and deodorization. But, drying and deodorization significantly reduced lightness of cocoa butter obtained after the step of washing.

The degree of greenness in Table 3 varied from -1.18 to -0.12. Except the last step, there was no significant difference between the ''a'' values over the first four treatments. Although we did not notice too many variations in greenness, the CV of 316.6% (filtration), 106.8% (clarification), 121.7% (washing and drying) and 16.10% (deodorization) were too high. Such high CV shows that the spectrocolorimeter was not consistent in appreciating the greenness of the cocoa butter. Although greenness was statistically the same from filtration through drying, we observed too high CV. These high CV might have derived from interference in measuring redness since the other color parameters (lightness and yellowness) were correctly appreciated.

As far as yellowness of the cocoa butter was concerned, the ''b'' values of 31.34 and 31.19 at filtration and clarification, respectively, with CV less than 5% were statistically the same. Like these two previous steps, washing and drying had ''b'' values of 33.08 and 33.02, respectively with CV less than 3%. Though, the step of deodorization significantly reduced the yellowness of the cocoa butter. Therefore, we noticed no significant difference between filtration and clarification as well as between washing and drying. The highest values were reached during washing and drying and the lowest value was observed during the last step. Like lightness, the highest degree of yellowness of the cocoa butter was obtained after washing. This brightness in the yellow color has been significantly reduced following heat treatment over drying and deodorization. Finally, the heat treatment also destroyed the pigments responsible of the yellow color as previously stated.

CONCLUSION

This study shows that lightness of cocoa butter significantly changes during the five stages of processing. According to the results exhibited in Table 3, the highest lightness (highest L value) which is 79.60 is obtained during washing, as this is the stage where all impurities are cleaned up and removed. We did not notice any significant difference in lightness between filtration (L = 77.28) and clarification (L = 77.68); between drying (L = 78.89) and deodorization (L = 78.50). As far as the degree of greenness is concerned, no significant difference was observed between the first four steps (filtration, clarification, washing and drying), but the butter was greener after the final step than any of the four previous treatments. The degree of yellowness did not differ between filtration and clarification and between washing and drying, but we did observe the lowest value (b = 27.58) of this parameter during deodorization.

Except greenness, intensities of lightness and yellowness were much higher after washing than any of the other steps of the processing. Washing was the processing step that provided the cocoa butter with the highest brightness and yellowness. Then, this processing step yielded the cocoa butter with the best color. The step of washing appeared as one of the most critical point among the others during the manufacturing of the raw cocoa butter obtained after partial defeating. As it has been previously reported, the Hunter L*a*b color system was efficient in appreciating color of cocoa butter (Mcglynn *et al*., 1993).

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