

Uses and quality assessment of cocoa butter sold in retail markets in Yaounde capital city, Cameroon

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ABSTRACT: This study was carried out to screen the uses and evaluate the quality of cocoa butter sold in local markets. A survey was conducted in markets of Yaoundé capital city. Thirty cocoa butter users and twenty sellers were directly interviewed. In assessing the quality of cocoa butter, five samples were randomly purchase and their physicochemical composition compare to a control. Coliforms and mould were looked for to asses the sanitary quality of the samples. Analysis of data shows that the majority of cocoa butter users are young people between 25-30 years old. Cocoa butter is generally used in therapy and then in cosmetic and finally as food. The majority of users are satisfied after using cocoa butter but the quality of the product remains their expectation. Cocoa butter sellers are mainly famers. Cold processing is the extraction method. The result of physicochemical analysis shows that four of the five samples bought on markets are adulterated. For all samples, contamination by coliform is less than the standard limit. The presence of mould was detected in two of the five samples analyzed which can be attributed to an inadequate processing or a post processing contamination.

Key words: cocoa butter, quality, adulteration, contamination

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1. Introduction

Cocoa, the fruit of *Theobroma cocoa* L., is one of the main cash crop produced by Cameroon farmers, since it represents an essential agricultural resource for about 400.000 farmers and provides about 40% of primary sector exports. Due to international price fluctuations of cocoa which influence the exportation system of the product, Cameroon farmers have developed dynamic reaction based by local processing of cocoa into butter and other derived products, creating thus a new activity in order to counteract the market price risk (Coulter and Etoa, 2010; Mounjouenpou et al., 2012). Artisanal cocoa butter is thus progressively appearing as one of the products currently sold on local markets, (La voix du Paysan, 2007; Mounjouenpou et al., 2014). This rapid growth of local cocoa butter market is probably supported by cosmetic and health benefits of cocoa butter largely publicized among populations. The publicity being based on scientific works documented on cosmetic, therapeutic, nutritional and health benefits of cocoa butter (Scheu, 2001; Rabasco Alvarez and González Rodríguez, 2000; Panganiban et al., 2012). Appraising the local uses of cocoa butter by populations appears of significant interest in order to evaluate the potential market development of the product. Meanwhile, the local cocoa butter production is also confronted with a quality problem, with regard to the low technological level of local processing material and conditions used, the relatively poor processing and hygienic knowledge of untrained practitioners, as far as product quality and control are concerned, and the risk of product adulteration due to actors interested only in economic profit offered by the new activity. Moreover, lack of official regulation concerning the quality of the local product enhances the risk of adulteration, the consequence being then the reduction of its health benefits and its acceptability by consumers. In fact consumers are more concerned with the quality of cocoa butter, in terms of efficiency and expected effects. In this respect, the quality of local cocoa butter remains an important issue for the development and the vulgarization of this product whose properties are well documented. The present paper aimed thus at screening, through a survey, the local uses, the artisanal processing practices, and the overall quality and acceptability of cocoa butter sold on local markets.

2. Material and methods

2.1 Field survey

2.1.1 Study area

The survey was conducted in markets of Yaoundé (longitude 3.86667x latitude 11.51667), a city situated in the center of one of the leading cocoa producing region in Cameroon. 15 market places were randomly chosen in each of the seven divisions of Yaoundé city according to the geographical position (Fig. 1). 20 sellers (among which 11 processors and 9 retailers) and 30 users (consumers) of cocoa butter were randomly interviewed on the whole markets (Table 1). The interview of participants was performed through open discussion using an interview guideline. Processors were interviewed on the processing techniques

used to extract cocoa butter, the quality attributes of the butter during processing. Sellers were questioned on the marketing objectives and consumers on their uses of cocoa butter and their appreciation of the product found on the market.

2.2 Quality evaluation of cocoa butter

Five cocoa butter were bought in Central market (Yaoundé I), Mokolo market (Yaoundé II), Ekounou market (Yaoundé IV), Medong Market (Yaoundé VI) and Nkolbison market (Yaoundé VII) according to geographical variability. Control sample was extracted in laboratory according to the traditional procedure described by Mounjouenpou et al, 2012.

2.2.1 Control cocoa butter sample extraction

The control sample was produced from 53 cocoa pods of *Forestaro* (high Amazonian) and *trinitario* varieties bought in a local plantation located in approximately 83 km of Yaoundé city. The ripe cocoa pods were opened, beans removed and fermented during 5 days using a wooden box measuring 50x50x50cm. The beans were regularly turned manually at preset interval in order to obtain a uniform fermentation. Fermented beans were sun dried for 10 days spread on an aluminum sheet to reduce beans moisture down to 10%. Dried cocoa beans were broken into nibs using hammer to facilitate removal of the shell by winnowing. The nibs were roasted at 135°C in a Memmert oven for 1 hour. They were then ground in stone mills to obtain cocoa liquor. The cocoa butter was extract using hot extraction method. Cocoa powder was mixed with water in a pot and cooked for several hours to extract the cocoa butter. Upper layer which represents the cocoa butter was collected, washed using distilled water and filtered using a clean tissue.

2.2.2 Physicochemical analysis

Physicochemical analyses were carried out for purchased cocoa butter samples and the control. Sensory evaluation of cocoa butter was carried out using qualitative descriptive analysis method from a panel of 10 trained people. The color, texture, odor and melting point of purchased cocoa butter samples were evaluated by comparison with control. The control cocoa butter sample had a standard description predetermined and accepted by the panelists. Samples were labeled with 3 digit alphabetical codes. Chemical alteration index for oil and fats were also carried out to asses the chemical quality of cocoa butter sample. Acid and peroxide values were determined according to the AOCS Official Method Cd 8-53, 2003 and AOAC 965.33 (2000) respectively. Saponification value was determined according to titrimetric method AOAC 920.160 (2000). Determination of Cholesterol was analyzed by the enzymatic procedure of Allain et al., 1974 after dissolution and saponification of the cocoa butter sample.

2.2.3 Microbiological analysis

2.2.3.1 Laboratory technique and analysis

All the material necessary for the analysis was sterilized during 1 hour by using a hot air oven (Binder FDL 115) at 170°C. Analyses were done under laminated flow cabinet disinfected with chlorine and in the presence of a flame to ensure that experimental materials were not contaminated from the laboratory.

2.2.3.2 Test for total coliforms

Coliforms was isolated and enumerated after culture and growth in Violet Red Bile Agar. Violet Red Bile Agar (28g) was weighed in an Erlenmeyer and sterilized water (100ml) was added. The Erlenmeyer was shut up with cotton and wrapped with aluminum foil. The mixture was boiled during 15 minutes by using an autoclave at 125°C. A volume of sample solution (8ml) was inoculated on Petri dishes with already prepared Violet Red Bile Agar. The Petri disk was incubated at 37°C during 24 hours. After incubation, spots and spread were counted and recorded as total coliform using the colony counter. The result was expressed in Unit Forming Colonies by ml (UFC / ml).

2.2.3.3 Test for moulds (Fungi)

Molds were isolated and enumerated after culture and growth in Sabouraud Dextrose Agar. A 65 g of Sabouraud Dextrose Agar at a concentration of 40 % (m/v) was weighed in an Erlenmeyer. Sterilized water (100ml) was then added. The mixture was boiled during 15 minutes by using an autoclave at 125°C. A volume of sample solution (8ml) was inoculated on Petri dishes with already prepared Sabouraud Dextrose Agar. The Petri disk was incubated at 37°C during 24 hours. After incubation, all white

spots and spread were counted and recorded as moulds using the colony counter. The result was expressed in Unit Forming Colonies by ml (UFC / ml).

3. Results and discussion

3.1. The artisanal cocoa butter production

3.1.1 Actors of the system

3.1.1.1 Cocoa butter users

The majority of cocoa butter users (Table 2) are young people between ages of 25-30 years (36.67%). They are followed by the elderly between 40-45 years (16.67%) and then 30-35 years (13.33%). These age categories represent the more active working group. On respondent's marital status, Table 3 showed that the proportion of married (50%) or single (50%) knowing and using cocoa butter are the same.

3.1.1.2 Cocoa butter sellers

Cocoa butter sellers (Table 3) are in majority farmers (60%). These farmers' sellers are found in Yaoundé I, II, III, V and VII subdivision markets. Retailers are most found in Yaoundé IV and VI subdivision markets. Farmer seller's Customers are loyal (60%) than retailer's customers. They are generally female with an age varying from 25 to 80 years.

3.1.2- The processing practices

In general, cold processing (Table 4) is the traditional extraction method (40%) and the majority of the respondents (93.33%) tell not to adulterate their product. The cost price varies from one seller to another and rang between 100 Francs a small plastic bag to 25000 Francs CFAper litter.

3.2 The local uses of local cocoa butter

Figure 2 shows that the cocoa butter is generally used in therapy (43.33%) and then in cosmetic (30%) and finally as food (26.67%). In therapy, it is mostly used as massage balm (20%) and after cardiovascular diseases histories (23.33%). Cocoa butter is also used after hemorrhoid history (13.33%) and in the vaginal cleaning (10%). In cosmetic, cocoa butter is more used (20%) as body milk and in food as drink (13.33%). Theses observations confirm that people are aware about the health and nutrition benefits of cocoa butter.

3.3 Acceptability of local cocoa butter

Table 5 shows that the majority of users (75%) are satisfied after using cocoa butter. Among the satisfied respondents, 44 % purchase cocoa butter anywhere and 33.33% buy it in supermarkets. Hence, the place of supply has no or little influences on user's satisfaction. However, among the minor unsatisfied (16.67%), a higher percent are unsatisfied when they buy cocoa butter from peddlers. Although satisfied in majority, the users were metabolized to express their needs. For the majority (37.5%), an accent must be put on the quality so that it can fill their expectation. Some users (20.83%) wishes to see the cost prices slowing down while others (20.83%) advocate for a good sensitization of populations about the properties of cocoa butter and also an increase in production.

3.4 Physico-chemical, hygienic and sensory quality of artisanal cocoa butter

3.4.1 Sensory evaluation

Table 6 presents the sensory evaluation of cocoa butter samples. Two of the five samples (BCK and BCM) have a colour different from the yellowish color of the control sample (BCT). These samples have a foreign odour different from the chocolate-like scent of the control. BCK has palm kernel oil-like scent and BCM motor oil-like scent. BCE sample which is yellowish in color has palm kernel oil -like scent. The three samples have a texture and melting temperature different from the control (BCT). Some are soft in texture and melt in sun (BCM and BCE) and other hard and melt at 34°C (BCK). BCN sample has a sensory profile less different from the BCT control sample. It is light yellow, hard in texture with a moderate chocolate -like scent and melts at 34°C. BCC is the only sample which has a sensory profile similar to the control one.

3.4.2- Chemical analyses

Table 7 presents the chemical alteration index, saponification value and cholesterol content of the various samples of cocoa butter.

3.4.2.1- Chemical alteration index of oil and fats

Acid value

Cocoa butter samples BCK ($1.44\text{g} \pm 0.06\text{g}$ of KOH/g of fatty acid), BCM ($2.12\text{g} \pm 0.09$ of KOH/g of fatty acid), BCC ($1.65\text{g} \pm 0.013$ of KOH/g of fatty acid), BCN ($1.96 \pm 0.13\text{g}$ of KOH/g of fatty acid) and BCE ($1.85 \pm 0.13\text{g}$ KOH/g of fatty acid) have higher acid value than the control sample BCT (0.99 ± 0.17 of KOH/g of fatty acid). These acid values are particularly high in BCM sample but lower than maximum required in level of codex standard reference value (4g of KOH/g of fatty acid).

3.4.2.2- Peroxide value

Cocoa butter samples BCK ($5.55\text{g} \pm 0.18\text{meq/Kg}$ of fatty acid), BCM ($25.06\text{g} \pm 0.44\text{meq/Kg}$ of fatty acids), BCC ($3.73 \pm 0.15\text{meq/Kg}$ of fatty acids), BCN ($5.86\text{g} \pm 0.61\text{meq/Kg}$ of fatty acids) and BCE ($6.12 \pm 0.95\text{meq/Kg}$ of fatty acids) have higher peroxides value than the control sample BCT ($1.32\text{g} \pm 0.59\text{meq/Kg}$ of fatty acids). The peroxide value of BCM sample is particularly higher and more than maximum given in the Codex standard peroxide value ($10\text{meq d'O}_2/\text{KG d'AG}$) for oil and fat deterioration.

3.4.2.3- Saponification value

Saponification value of samples BCM (11.53mg KOH/g) and BCE (12.41 KOH/g) are higher compared to samples BCK (1.33 KOH/g), BCN (1.36 KOH/g) and control sample BCT (1.28 KOH/g). But those values are lower than those regulated by the codex standard permissibility level (codex-stan 210-1999).

4.2.4- Cholesterol estimation

The contents in cholesterol of samples BCK (0.66), BCM (2.32), BCN (0.38) and BCE (0.35) are 29 to 193 times higher than BCC sample (0.011) and the control sample BCT (0.012) which are practically similar. If BCT sample is taken as control, this observation confirms that BCK, BCM, BCN and BCE samples are not pure.

The chemical profiles analyzed are different from one sample to another. The trend of were analyzed by using Principal Component Analysis (PCA) and Hierarchical Cluster Analysis (HCA). Figure 3-6 showed the results of the PCA on the cocoa butter samples. The first Principal Components (PCs) were able to explain 75.35% of the total variance and all the variables are well represented on this axis (Figure 3 and 4). Figure 5 show a representation of variables and cocoa butter samples according to the first two principal components F_1 and F_2 which explain 89.99% of variance. Spatial distribution of samples well differentiate cocoa butter sample BMC from control sample BCT. BMC sample has the highest IA, IP, IS and cholesterol (Chl) values while the control BCT has the lowest. Hierarchical Cluster Analysis confirms this result. Figure 6 shows the cluster dendrogram which group samples into five classes according to the degree of similarity in chemical profile.

4.3- Microbiological analyses

The presence of coliforms and mould reflects the sanitary quality of cocoa butter. Microbial analysis shows (Table 9) that the level of total coliforms is lower than the standard limit in all samples. Two of the five samples (BCK and BCN) have a higher quantity of mould than the standard limit. They are not acceptable for local consumption or export.

Discussion

Young people are the higher user of cocoa butter. This can be understandable because they are well informed about it properties and are also vulnerable to diseases. Youth represent more than 50 % of Cameroonians population and they are the most cocoa demanding force. Hence, local processing of cocoa butter is a good business activity since the product can be easily sold. Cocoa butter sellers are in majority farmers and the cost price is not fixed. This highlights the problems of raw material availability and price variability. Farmers are owners and when deciding, they can do well the business because of the availability of the raw materials. The farmer seller's customers loyalty can be understandable because doing a business with such a seller, they are sure that they can easily get their product and at any time. As stated by many authors, food price variability is the common feature of sub-Saharan Africa economy. Cocoa butter is used in therapy, in cosmetic and as food. Theses observations confirm that people are aware about the health and nutrition benefits of cocoa butter. It highlights the emollient and anti-inflammatory properties of cocoa butter and the role in the fighting against cardiovascular diseases as stated by many authors. Used externally as massage

balm, cocoa butter promotes relaxation and the feeling of well-being. This property is due to the presence of cocoa mass (CM) polyphenol a substance that inhibits the production of the immunoglobulin IgE and thereby reducing inflammation and helping to relieve sore muscle pain and arthritis (Khan et al., 2014). Many studies have proved the role of cocoa butter in the prevention of cardiovascular diseases (atherosclerosis, coronary, thrombosis and cerebral haemorrhage). This has been related to the high content in oleic and stearic acid and the presence of CM polyphenol (Monsma et al., 1996; Scheu et al., 2001; Panganiban et al., 2012). No report has been stated for its use in vaginal cleaning. Cocoa butter is high in fatty acids. Thus, it can easily penetrate deep-down into the skin and hydrate from within (Ribier et al., 1997). Cocoa butter is naturally rich in Vitamin E as well as a number of other vitamins and minerals. Vitamin E helps to soothe, hydrate, and balance the skin and also provides the skin collagen which assists with wrinkles and other signs of ageing. This explains why it is used as cosmetic such as body milk. Topical treatments of hemorrhoid involve the use of suppositories, ointments and anorectal pads (Borod, 2001). Due to its anti-inflammatory properties, it is obvious to see that some respondents use cocoa butter in treatments of hemorrhoids. Cocoa butter contains 33% oleic acid, 25% palmitic acid and 33% stearic acid. Use as drink, it has beneficial effect. It has been shown to lower cholesterol and triglyceride level and also to modulate immune response and antioxidant enzyme systems. Cocoa butter contains CM polyphenol associated with lower risk of cardiovascular diseases. As a fat, cocoa butter is nourishing. It contains minerals and vitamins which can help to alleviate micronutrients deficiencies. Cocoa is food and cocoa is a medicine (Dillinger et al., 2000). Hence local consumption of cocoa and cocoa products should be encouraged in the prevention of cardiovascular diseases. With the evidence of its health and nutritional properties, cocoa and cocoa products could be included not only in medicinal therapeutics but also in many feeding programs. As stated by Essegbey and Ofori-Gyamfi (2012), getting school children to appreciate cocoa products enables them to grow with the habit and entrench cocoa consumption in the coming generations. Cocoa butter sold in markets give satisfaction after using but the quality of the product remains a strong expectation for the users. Except for external use, the health benefits of cocoa butter are observed after ingestion and there must be a balance between quality and benefits resulting from ingesting cocoa butter with respect to the risk involved to public health. Hence, a good quality insurance policy should be put in place. Two samples (BCK and BCM) bought in market have an off odor and color. Three samples ((BCM, BCE and BCK) have a texture and melting temperature different from the control. They seem to be a mixture of different oils or other materials. Although, the alteration index values shows that samples' qualities are still good but they are already in a process of degradation marked by the presence of free fatty acids and peroxides. As stated by many authors, higher acid value is indicative of higher free fatty acid which translates into decreased fat quality. Long storage of BCM sample may be responsible for the highest acid and peroxide values (Atinafu and Bedemo, 2011; Okpuzor et al., 2009). The product has stayed long (1 year) and the oxidation of lipids is a time depend phenomenon. The more the product is kept for longer time, the more it will oxidize (Atinafu and Bedemo, 2011; Okpuzor et al., 2009). Higher saponification value indicates high proportion of lower fatty acid since saponification value is inversely proportional to the molecular weight or chain length of fatty acids (Okpuzor et al., 2009. Orhevba et al., 2013) Higher saponification value obtain for samples BCM and BCE indicate that they contain high amount of short chain fatty acid (C_{12}). Lower saponification value of samples BCK, BCN and BCT shows that they have high content in long chain fatty acid. It is also obvious that the control sample BCT contains long chain fatty acid since pure cocoa butter is made of triglycerides which result mainly from a combination of three long chain fatty acids: palmitic acid (C16:0), stearic acid (C18:0) and oleic acid (C18:1) (Lipp and Anklam, 1998). BCN sample is an adulterated sample assert by its seller as a mixture of cocoa butter and groundnut oil. Comparable content in cholesterol (BCE) or even higher (BCK (0.66) and BCM (2.32)) than the adulterated sample BCN is a proof that the samples are adulterated. The chemical profiles of all cocoa butter samples bought on market are different to the control sample BCT and the trend varies among the samples. BMC sample has the highest dissimilarity. It forms a single class with the highest value for all the parameters analyzed. This result proves that it is not a pure sample. Its white color with a motor oil-like scent confirms that it is adulterated. BCE sample forms another class with a chemical profile highly different to the others samples. It is characterized by a higher IS value. Its sensory profile (soft texture, palm kernel oil -like scent), different from the control sample BCT confirms that it is also adulterated. BCK and BCN are in the same class. This means that they have a similar chemical profile. BCN is a mixture of groundnut oil and cocoa butter as stated by the seller. By similarity, one can say that BCK is also a mixture of oil. This can be confirmed by its moderate chocolate-like scent. These two samples are different to BCC sample which form a distinguished class. The chemical profile of BCC sample which was seemed to be similar to the control sample BCT is different. The two samples (BCC and BCT) have the same sensory profile. The difference in chemical profile can be attributed to the extraction process since they are freshly made samples. BCT is produced by a control protocol while BCC is produced empirically. Although the majority of the respondents (93.33 %) tell not to adulterate their product, this is not confirmed by physicochemical analysis and in conclusion four of the five samples seem to be adulterated. Cocoa butter is a fat and wetting is a favorable condition for microbial contamination. Bacterial grow under specific conditions. They need higher water activity and the lower bacterial contamination can be explained by a low or no water content. Moulds are less demanding in water. The presence of mould in samples BCK and BCN reflect an inadequate processing or a post

processing contamination rather than an extended shelf life because BCM which is the oldest sample (one year and more) still has a good sanitation profile.

4. Conclusion

The objective of this study was to screen the uses and evaluate the quality of cocoa butter sold in local markets. The result of the study highlights that the majority of cocoa butter users are young people between ages of 25-30 years. Cocoa butter is generally used in therapy then in cosmetic and finally as food. In therapy, it is mostly used as massage balm and after cardiovascular diseases histories. The majority of users are satisfied after using but they need that an accent should be put on the quality so that it can fill their expectation. Cocoa butter sellers are in majority female farmers and cold processing is the extraction method in general. The cost price is not fixed. The majority of the respondents tell not to adulterate their product but the results of physicochemical analysis do not confirm it. The five cocoa butter samples bought on market shows a chemical profiles different to the control and 4 (BCK, BCM, BCN and BCE) of the five samples seem to be adulterated. Contamination by total coliform is less than the standard limit for all the samples. The presence of mould was detected in two (BCK, BCN) of the five samples analyzed. The presence of mould in samples reflects an inadequate processing or a post processing contamination.

Conflict of interest

The author declare that there are not conflicts of interest

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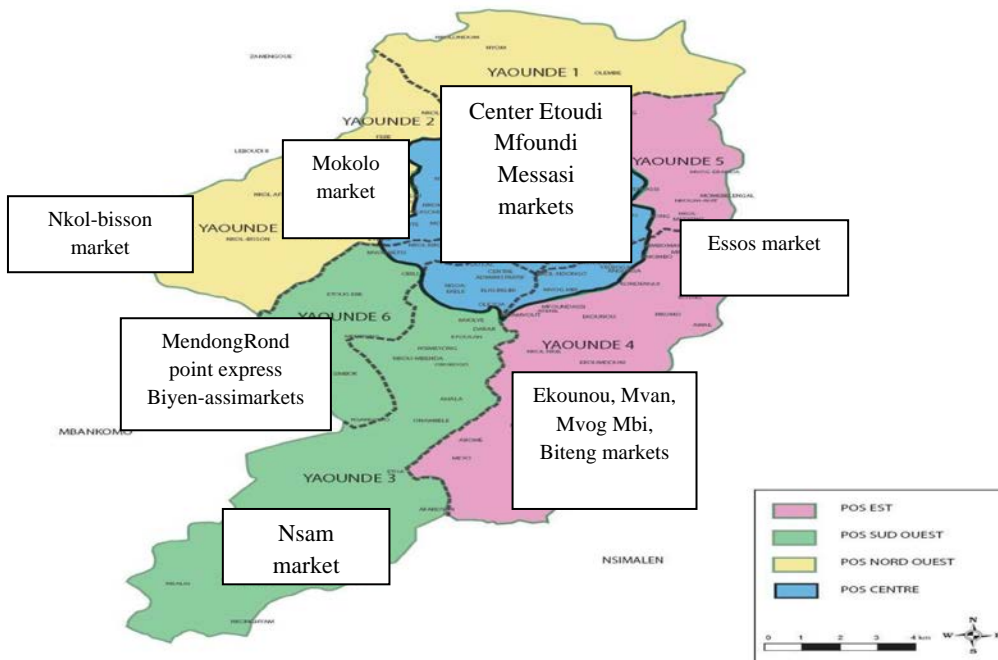


Figure 1: Distribution of survey market

Table 1: Distribution of the cocoa butter users and sellers

Subdivision	Geographic Position	Markets	Numbers of sellers producer of cocoa	Numbers of retailers	Numbers of cocoa butter users
Yaoundé I	Centre	Central	2	1	10
	North West	Etoudi	1	0	7
	Center	Mfoundi	1	0	0
	North West	Messasi	0	1	0
Yaoundé II	North West	Mokolo	1	0	0
Yaoundé III	South West	Nsam	1	0	0
Yaoundé IV	East	Ekounou	0	1	4
		Mvan	1	0	0
		MvogMbi	0	1	0
		Biteng	0	1	0
Yaoundé V	East	Essos	1	0	0
Yaoundé VI	South West	Mendong	1	1	5
		Rond point express	0	2	0
		Biyem-assi	0	1	0
Yaoundé VII	North West	Nkolbisson	2	0	4
Total		15	11	09	30

Table 2: Frequency distribution of cocoa butter user according to the age and marital status

Age		
A	F	P
g	r	e
e	e	r
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c	u	e
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Table 3: Frequency distribution of cocoa butter sellers according to their age, gender, activity and the behavior of their customers

District	Market	Customer range of age	Customer's Gender	Activity of sellers	Customer's loyalty	Processing price and satisfaction
Yaoundé I	Central	30-80	Mix	Farmer	loyal	
	Etoudi	25-55	Female	Farmer	loyal	
	Mfoundi	30-65	Female	Farmer	loyal	
Yaoundé II	Messassi	20-50	Female	Farmer	Unloyal	Market Extraction method Seller Adulteration satisfaction Cost price
	Mokolo	25-55	Female	Farmer	loyal	
Yaoundé III	Nsam	30-80	Mix	Farmer	loyal	
Yaoundé IV	Ekounou	30 et +	Female	Retailer	Unloyal	
Yaoundé I	Centre Mvan	21-55	Cold Female	Pure Retailer	Yes Unloyal	200-2000
	North west MvogMbi	30-45	Semi Cold and Hot Female	Pure Retailer	Yes Unloyal	100-20000
Yaoundé V	Centre Biteng	25-60	Hot Female	Mixture Retailer	Yes Unloyal	300-25000
	North west Essos	30-80	Hot Mix	Farmer	I can not know Unloyal	1500-18000
Yaoundé VI	Mendong	40 et +	Hot Female	Pure Retailer	I can not know Unloyal	
	Rond point express	30-80	Mix	Farmer	I can not know Unloyal	100-20000
Yaoundé III	Biyem-assi	28-70	know Mix	Retailer	Yes Unloyal	200-20000
Yaoundé VII	Nkolbisson	25 et +	Cold Female	Pure Farmer	Yes loyal	
Yaoundé IV Total	East 15	Ekounou 15	Hot 15	Pure 15	Yes 15	2000
		Mvan	Cold	Pure	Yes	200-25000
		MvogMbi	Cold	Pure	Yes	100-22000
		Biteng	I don't know	Pure	Yes	200-19000
Yaoundé V	East	Essos	Cold	Pure	Cold	200-20000
Yaoundé VI	South west	Mendong	I don't know	Pure	I can not know	3250
		Rond point express	Cold	Pure	Yes	200-2000
		Biyem-assi	I don't know	Pure	Yes	3500
Yaoundé VII	North west	Nkolbisson	Hot	Pure	Yes	2000
Total		15				

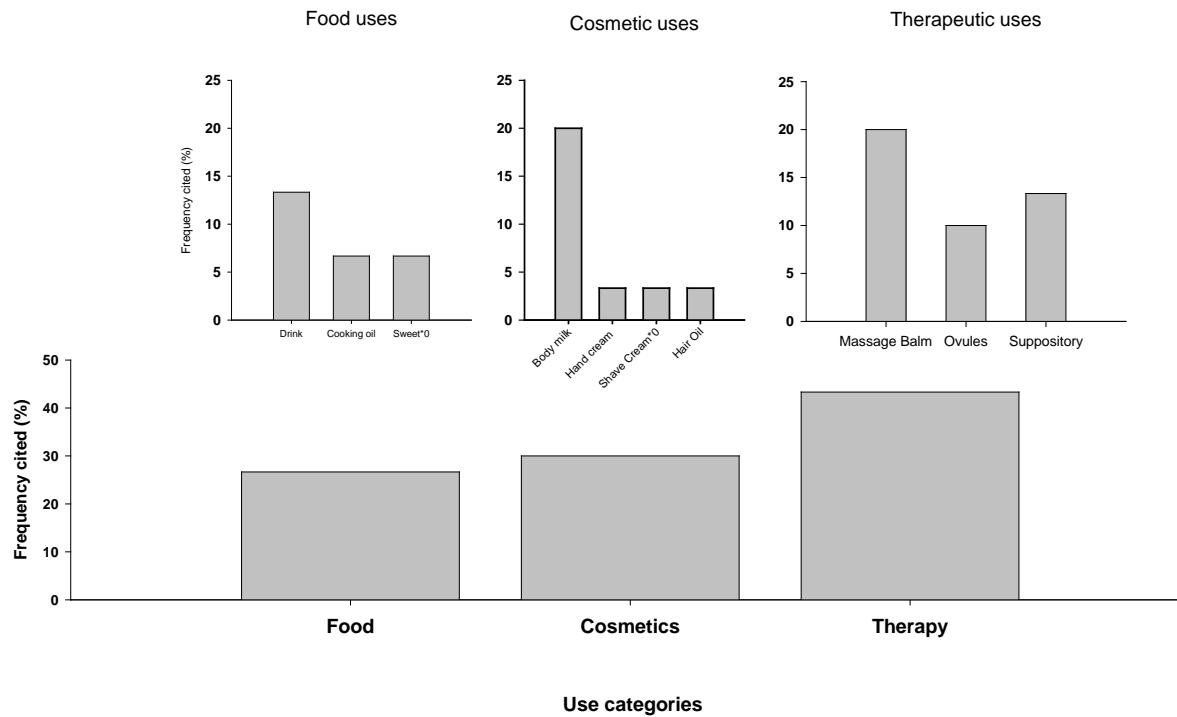


Figure 2: Main uses of artisanal cocoa butter

Table 5: State of satisfaction and needs for the customer.

User's satisfaction			
State of satisfaction	Percentage		
Unsatisfied	4	16.67%	Peddle 3 Supermarket 1
Mitigated	2	8.33%	No fixed place 1 Supermarket 1
Satisfied	18	75%	Central market 1 No fixed place 8 Producer 1 Religious women 2 Supermarket 6
Total	24	100%	24
User's needs			
User's needs	Frequency	Percentage (%)	
Reduction of the cost price	5	20.83%	
Good quality of cocoa butter	9	37.5%	
Liquefaction of cocoa butter	1	4.17%	
Reorganization of the sector for a higher production	3	12.5%	
Sensitization on the properties of cocoa butter and an increase in production	5	20.83%	
Subvention from the state	1	4.17%	
Total	24	100%	

Table 6: Sensory evaluation result of cocoa butter samples from different markets

Samples	Color	Odour	Hardness	Melting temperature
BCK	Light brown	Palm kernel oil-like scent	Hard	Melt at 34°C
BCM	White	Motor oil-like scent	Soft	Melt in sun

BCC	yellowish	Chocolate-like scent	Very hard	Melt at 34°C
BCN	Light yellow	Moderate chocolate-like scent	Hard	Melt at 34°C
BCE	yellowish	Palm kernel oil-like scent	Soft	Melt in sun
BCT	yellowish	Chocolate-like scent	Very hard	Melt at 34°C

Table 7:Chemical alteration index, saponification value and cholesterol estimation of cocoa butter samples

Market	Age of cocoa butter	Seller adulteration assertion	Extraction process	Code	Acid value	Peroxide value	Saponification value	Content in cholesterol
Center	2 days	Pure	Cool	BCC	1,65 ± 0,01	3,73 ± 0,15	3,29	0,011
Mokolo	1 day	Pure	Hot and cool	BCE	1,85 ± 0,13	6,12 ± 0,95	13,41	0,35
Ekounou	4 months	Pure	Hot	BCK	1,44±0,06	5,55 ± 0,018	1,33	0,66
Mendong	More than one year	Pure	-	BCM	2,12±0,09	25,06 ± 0,44	11,53	2,32
Nkol-bisson	2 weeks	Mixture	Hot	BCN	1,96±0,13	5,86 ± 0,61	1,36	0,38
		Pure		BCT	0,99±0,17	1,32±0,59	1,28	0,013
					<4g KOH/g Fat	10meq d'O ₂ /KG of Fat	190-209 mg KOH/g fat	0,013
					Codex Alimentarius 1999	Codex Alimentarius, 1999	Codex alimentarius 1999	Bruneton, 1999

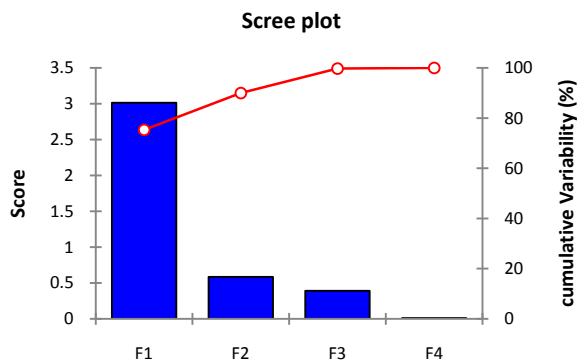


Figure 3: Scree plot of cocoa butter sample according to respective variance (%)

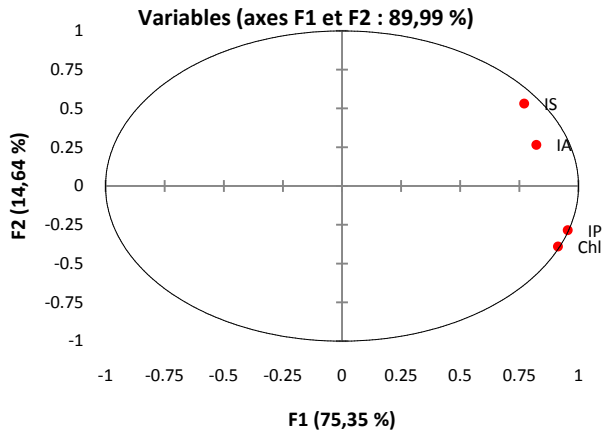


Figure 4: Circle of correlation of variables

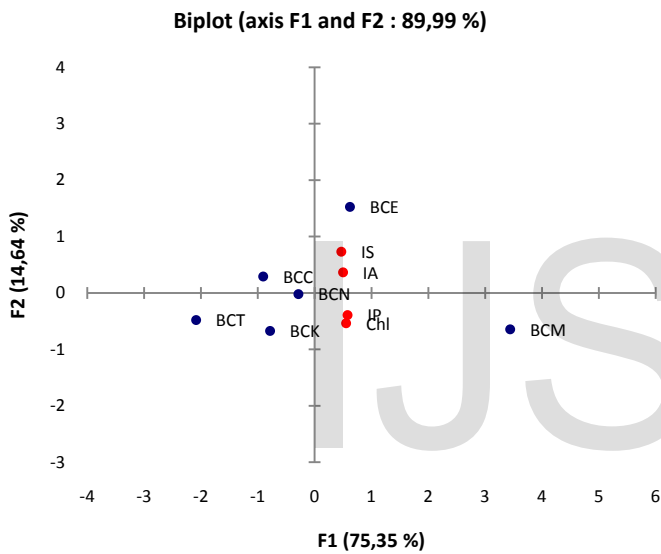


Figure 5: Representation of variables (IA, IP, IS, Chl) and cocoa butter samples according to the first two principal components F₁ and F₂

Variables were labeled with 2 digit alphabetical codes. IA: acid index; IP: peroxide index; IS: saponification index; Chl: cholesterol. BCC, BCE, BCK, BCM, BCN, BCT are cocoa butter samples.

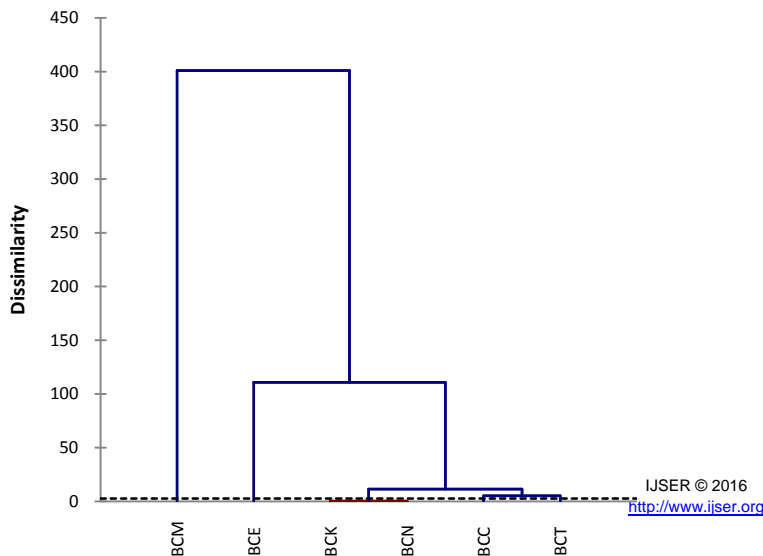


Figure 6: Cluster dendogram grouping cocoa samples in classes

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