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FUNCTIONAL PROPERTIES OF FERMENTED AND UNFERMENTED COCOA PLACENTA POWDERS (*THEOBROMA CACAO* L.) FOR THE PRODUCTION OF BISCUITS

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Abstract: *This study aims to examine the effects of fermentation on the functional properties of placenta powder for their use in the food industry. Cocoa placenta from freshly harvested pods was used for this study. A part was fermented, dried, crushed and sifted to obtain fermented cocoa placenta powder. The other part was not fermented but underwent the same steps to have an unfermented cocoa placenta powder. Standard and referenced methods have made it possible to measure certain functional properties of these cocoa placenta powders. Thus, the results showed that the fermentation increased the water absorption capacity (514.65%), the packed density (10.37g/mL), the clarity of the dough (2.13%) compared to to unfermented placenta powder which recorded rates of 496.50% for water absorption capacity, 9.34 g/mL for packed density and 1.86% for dough clarity. However, the solubility index of fermented cocoa placenta powder (15.45%) is lower than that of fermented powder (29.55%). These powders are able to easily disperse in water, giving a homogeneous solution. Moreover, the wettability value of unfermented cocoa placenta powder (4.09s) is higher than that of fermented powder (2.09s). Fermented cocoa placenta powder dissolves in water much faster than unfermented one. In addition, the oil absorption capacity (OAC) was higher in unfermented cocoa placenta powder with unrefined palm oil (270%). The functional properties of these flours have shown their importance for each measured parameter and can be useful in food technology processes for the formulation of foods, particularly in biscuits and bread making.*

Keywords: *Fermentation, functional caracteristics, cocoa, food industry, drying.*

1. Introduction

Cocoa (*Theobroma cacao*) is highly prized to produce chocolate from its beans. But the other parts of this plant, which are the empty pods and the placenta, are rejected in nature, as are the by-products of the fruits after using the edible parts (pulps) and almonds [1, 2, 3]. Thus, in most cocoa plantations in Africa and particularly in Côte d'Ivoire, the placenta of the cocoa, which is considered waste, is rejected into nature, after the cocoa is shelled to extract the beans. However, fresh beans represent only 20% of the mass of the pod and the other 80% are made up of cocoa waste such as empty cocoa pods, the juice from the mucilage and the cocoa placenta [4, 5]. These by-products of the transformation of cocoa into market beans have been the subject of interesting valorization (manufacture of fertilizers, liqueurs, wines, marmalades, etc.) except for the cocoa placenta which has been little valorized [6, 7].

However, some studies have shown that empty pods (cocoa fruit skin) and cocoa

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placenta are rich in nutrients and antioxidants that could be useful in human and animal nutrition [8, 9, 10, 11]. Cocoa fruit skin and cacoa placenta contains theobromine alkaloid (3,7 - dimethylamine) which is a limiting factor in the use of cocoa waste as animal feed. To increase the nutritional value and reduce theobromine content the usual use of fermentation. Fermentation is one of the technologies to increase the nutritional value of high fiber feed. Fermentation can hydrolyze protein, fat, cellulose, lignin, and other polysaccharides, so the fermented material will have higher digestibility, fermentation will increase total digestible nutrient [12].

This work aims to contribute to the valorization of the cocoa placenta through its use in the food industry, particularly in biscuits.

Biscuits are food products generally made from a dough made from wheat flour, sweeteners, fat, water, and many other additives [13, 14, 15]. The wheat flour dough used in the manufacture of biscuits could be partly replaced by cocoa placenta powder dough easily available and accessible in the cocoa producing regions of Côte d'Ivoire. Indeed, it is a question of proceeding to the formulation of foods enriched in nutrients by incorporating cocoa placenta powder for the manufacture of biscuits.

However, several factors can influence the rheological characteristics of the dough and the quality of the biscuits. These include the ingredients used, the conditions of kneading, rest and molding after kneading, cooking and cooling [13, 14, 15, 16].

Thus, after baking, the biscuits are able to retain their rheological, organoleptic and commercial qualities for a given time depending on their composition.

Normally, wheat flour is the main ingredient in cookies. Other flours such as cassava, sweet potato, maize, rye, plantain, etc. can be added to this ingredient [14, 17]. The technological goal of this action is to obtain composite flours to reduce production costs and also to create new products with innovative organoleptic qualities [17].

For this study on the formulation of biscuits enriched with cocoa placenta, two types of cocoa placenta powder were used. Indeed, according to Gbogbri [18], fermentation is one of the important steps involved in the transformation of cocoa beans. This step is essential in determining the quality of the aroma of the cocoa. Much of the world's cocoa supply undergoes fermentation, but significant quantities of cocoa are intentionally unfermented and immediately dried. These beans (fermented and unfermented) are commonly available commercially. Thus, one batch of cocoa placenta powder that has undergone fermentation and another batch of unfermented cocoa placenta powder will be used for this study. The functional properties of fermented and unfermented cocoa placenta powders were measured to determine which type of cocoa placenta powder would best suit the biscuit formulation.

2. Material and methods

2.1. Material

The plant material of this study is the cocoa placenta, which is extracted from cocoa pods at physiological maturity, freshly harvested from cocoa plantations in the Center-West of Côte d'Ivoire.

2.2. Methods

2.2.1 Production method of cocoa placenta powders

The cocoa placenta is subdivided into two batches.

Batch 1 consists of cocoa placenta fermented for 3 days with the beans using traditional fermentation methods, dried in an oven for 3 to 5 days and reduced to fermented cocoa placenta powder. The second batch consists of fresh unfermented cocoa placenta, dried in the oven for 3 to 5 days and reduced to powdered unfermented cocoa placenta.

2.2.2. Methods for determining the functional properties of flours.

Water Absorption Capacity and Water Solubility Index

The water absorption capacity (WAC) and the water solubility index (WSI) of fermented cocoa placenta and unfermented cocoa placenta flours were determined by the method of Adebowale *et al*. [19] and Phillips *et al.* [20] respectively. Two grams of fermented or unfermented placenta flour were separately dissolved in 50 mL of distilled water contained in centrifuge tubes. After stirring for 30 min with a magnetic stirrer, the solutions were kept in a water bath at 37°C for 30 min. The resulting mixtures were centrifuged at 5000 rpm for 15 minutes and the pellets were weighed and then dried at 105°C to constant mass.

The water absorption capacity was calculated by the following formula 1:

$$WAC\ (\%) = \frac{M2 - M1}{M1}\ x\ 100 \qquad (1)$$

WAC: Water Absorption Capacity,
M1: Mass of dried pellet,
M2: Mass of the wet pellet.

Water solubility index was calculated by the following formula 2:

$$WSI\ (\%) = \frac{M0 - M1}{M0}\ x\ 100 \qquad (2)$$

WSI: Water Solubility Index,
M0: Mass of the flour,
M1: Mass of dried pellet.

Wettability

The wettability of fermented cocoa placenta and unfermented cocoa placenta flours was determined according to the technique of Onwuka [21]. One gram of flour was placed in a 25 mL graduated cylinder with a diameter of 1 cm. Next, a finger was placed over the opening of the test tube to avoid spilling the sample. The finger used to close the test tube was placed at a height of 10 cm from the surface of a 600 mL beaker containing 500 mL of distilled water. The finger was removed and the sample was poured into the beaker. Wettability was determined as the time required for the sample to become completely wet.

Bulk density, packed density and porosity

The bulk density (BD) of fermented cocoa placenta and unfermented cocoa placenta flours was determined according to the method of Narayana & Narasinga [22]. As for the packed density (PD), it was determined using the modified technique of Oladele and Aina [23]. Fifty grams of flour were placed in a 100 mL graduated cylinder. The initial volume of this sample was noted after leveling the surface with a spatula. Then, the test tube was gently tapped on the bench until a constant volume was obtained. Bulk density, tapped density and porosity were calculated according to the following mathematical relationships :

$$PD\ (g/mL) = \frac{MS}{V0} \qquad (3)$$

DB: Bulk density,
MS: Sample mass,
V_0: Volume of sample noted after levelling.

$$BD\ (g/mL) = \frac{MS}{Vt} \qquad (4)$$

DP: Packed density,
MS: Sample mass,
Vt: Volume of sample noted after tapping.

$$P\ (\%) = \frac{V0 - Vt}{V0}\ x\ 100 \qquad (5)$$

P: Porosity,
Vo: Volume of sample noted after good levelling,
Vt: Volume of sample noted after tapping.

Foaming capacity

The foaming capacity (FC) of fermented cocoa placenta and unfermented cocoa placenta flours was determined according to the method of Coffman and Garcia [24]. Three grams of sample were transferred into a 50 mL graduated cylinder previously dried in an oven at 50°C. The flours were leveled and 30 mL of distilled water was added to the sample to facilitate the dispersion of the flour in the test tube. This volume was also noted (volume before homogenization); then the test tube was shaken vigorously by hand and the new volume was read on the test tube (volume after homogenization). The volume of the foam obtained was calculated by taking the difference between the volume after homogenization and the volume before homogenization. The sample was left to rest on the bench until the foam collapsed and at each time interval (every 10 min) the volume of the foam was determined. The foaming capacity (FC) of the mixed flours was calculated from the following formula 6 :

$$FC\ (\%) = \frac{Volume\ after\ homogenization - Volume\ before\ homogenization}{Volume\ before\ homogenization}\ x\ 100 \qquad (6)$$

Dough clarity

The clarities of the doughs of fermented cocoa placenta and unfermented cocoa placenta flours were measured according to the method of Craig *et al*. [25]. A mass of 0.2 g of flours of cocoa placenta was dissolved in 20 mL of distilled water contained in a centrifuge tube. The mixture was homogenized with a vortex, then heated in boiling water at 100°C for 30 min. During this heating, the mixture was homogenized every 5 min. After this heat treatment, the mixture was cooled on the bench for 10 min. The clarity of the sample paste was determined by measuring the transmittance at 650 nm on a spectrophotometer (PG Instruments, England) against distilled water.

Oil absorption capacity

Oil absorption capacity (OAC) of fermented cocoa placenta and unfermented cocoa placenta flours was tested using four different oils (refined palm oil, olive oil, sunflower oil and unrefined palm oil). The oil absorption capacity was determined according to the method of Sosulski [26]. One gram of the placenta flour was dispersed in 10 mL of each oil. After stirring for 30 min using a magnetic stirrer, the mixture was centrifuged at 4500 rpm at 4°C for 10 min and the supernatant was collected and the pellet was recovered and weighed on a SATORIUS precision balance. OAC was calculated by the following formula:

$$OAC\ (\%) = \frac{M1 - M0}{M0}\ x\ 100 \qquad (7)$$

OAC: Oil Absorption Capacity,
Mo: Flour mass,
M1: Mass of pellet.

Hydrophilic Lipophilic Ratio

The hydrophilic-lipophilic ratio (HLR), as defined by Njintang *et al.* [27], was calculated as the ratio of water absorption capacity to oil absorption capacity. This ratio makes it possible to evaluate the comparative affinity of flours for water and oil.

$$HLR\ (\%) = \frac{WAC}{OAC} \qquad (8)$$

HLR: Hydrophilic-Lipophilic Ratio,
WAC: Water Absorption Capacity,
OAC: Oil Absorption Capacity

Dispersibility

The dispersibility (D) of fermented cocoa placenta and unfermented cocoa placenta flours was determined according to the method described by Mora-Escobedo *et al.* [28].

10 mL of distilled water were added to 1 g of flour contained in a graduated cylinder. The mixture was stirred thoroughly by hand for 2 min.

Flour dispersibility was defined as the difference between the total volume of particles just after manual stirring and the volume of deposited particles recorded at time t (min).

$$D\ (\%) = \frac{V0 - Vt}{V0}\ x100 \qquad (9)$$

D: Dispersibility,
V_0: Volume of particles just after manual stirring,
Vt: Volume of deposited particles recorded at time t (min).

Statistical Analysis

All experimental data obtained were subjected to analysis of variance (ANOVA) procedure of SPSS version 15.0 (SPSS Inc., 2006). The difference between mean values was determined by the least significant different test. Significance was accepted at the 5% probability level.

3. Results and discussion

The results of some functional properties of fermented and unfermented cocoa placenta powder are shown in Table 1. The wettability of unfermented cocoa placenta powder (4.09 s) was almost twice that of placenta from fermented cocoa (2.09 s). As for the apparent density, it is substantially equal for fermented and unfermented cocoa placenta powder with respective values of 0.69 and 0.64 g/mL.

Regarding the packed density, the clarity of the paste and the water absorption capacity, the values of the fermented cocoa placenta powder (10.37g/mL, 2.13%T, 514.65%) are higher than that of unfermented cocoa placenta (9.34g/mL, 1.86%T, 496.50%).

The foaming capacity, porosity, and water solubility index of unfermented cocoa placenta powder with respective values of 11.62%, 26.56% and 29.55% showed higher values than fermented placenta powder (8.64% for foaming ability, 20.87% for porosity and 15.45% for WSI).

Statistical analysis showed that there is a significant difference between the values of wettability, tapped density, foaming ability, dispersibility, paste clarity, WAC, porosity and WSI of powder from fermented cocoa placenta and that of placenta from unfermented cocoa at the 5% level.

Values are means ± standard deviation. Means not sharing a similar letter in a row are significantly different ($p \leq 0.05$) according to Duncan's test.

WAC = water absorption capacity; WSI = water solubility index.

The oil absorption capacity (OAC) results reported in Table 2 showed that the highest OAC values were obtained with the unfermented cocoa placenta powders for each oil compared with those of the cocoa placenta fermented. OAC was higher in unfermented cocoa placenta powder with unrefined palm oil (270%).

The OAC of unfermented cocoa placenta powder with olive oil (206.67%) is twice as high as that of fermented cocoa placenta (106.67%). On the other hand, the OAC of cocoa placenta powder with refined palm oil (176.66%) is closer than that of fermented cocoa placenta (156.67%). It is the same for the OAC of placenta powder of unfermented cocoa and fermented with refined sunflower oil with respective values of 153.33% and 140.0%.

Table 1.

Some functional properties of fermented and unfermented cocoa placenta powders

Parameter	Cocoa placenta powder	
	Unfermented	Fermented
WAC (%)	496.50±12.37[a]	514.65±43.58[b]
WSI (%)	29.55±1.02[b]	15.45±4.73[a]
Wettability (s)	4.09±0.03[b]	2.09±0.03[a]
Bulk density (g/mL)	0.69±0.00[a]	0.64±0.00[a]
Packed density (g/mL)	9.34±0.89[a]	10.37±0.54[b]
Foaming capacity (%)	11.62±2.96[b]	8.64±2.08[a]
Dough Clarity (%)	1.86±0.06[a]	2.13±0.04[b]
Porosity (%)	26.56±0.69[b]	20.87±0.42[a]

Table 2.

Oil absorption capacity (OAC) of fermented and unfermented cocoa placenta flours

Oils used	Oil absorption capacity of cocoa placenta flours (%)	
	Unfermented	Fermented
Refined palm oil	176.66±6.55[b]	156.67±0.77[a]
Refined sunflower oil	153.33±0.77[b]	140.00±5.00[a]
Refined olive oil	206.67±15.27[b]	106.67±10.27[a]
Unrefined palm oil	270.00±5.00[b]	193.33±0.77[a]

Values are means ± standard deviation. Means not sharing a similar letter in a row are significantly different ($p \leq 0.05$), according to Duncan's test.

Table 3 presents the results of the hydrophilic-to-lipophilic ratios (HLR) of the placenta powders of fermented or non-fermented cocoa as a function of the oils used. The results show that powders from fermented cocoa placenta have higher HLR than those from unfermented placenta for all oils used in this work. Fermented cocoa placenta powder has twice the HLR value (5.11) than unfermented cocoa placenta powder (2.51) in the case of refined olive oil.

Table 3.

Hydrophilic to lipophilic ratio (HLR) of cocoa placenta flours

Oils used	Hydrophilic to lipophilic ratio of flours from cocoa placenta	
	Unfermented	Fermented
Refined palm oil	2.82± 0.18[a]	3.28± 0.20[b]
Refined sunflower oil	3.24±0.20[a]	3.70± 0.54[b]
Refined olive oil	2.51± 0.38[a]	5.11± 1.07[b]
Unrefined palm oil	1.84± 0.02[a]	2.66± 0.24[b]

Values are means ± standard deviation. Means not sharing a similar letter in a row are significantly different ($p \leq 0.05$), according to Duncan's test.

Unfermented cocoa placenta flour disperses faster in water than fermented cocoa placenta flour. At a time, t = 10 minutes, the cocoa placenta flour has reached its maximum dispersibility (50%) while the fermented cocoa placenta flour continues to disperse (45% at t = 10 minutes) to stabilize at 46.66% at t=15 minutes.

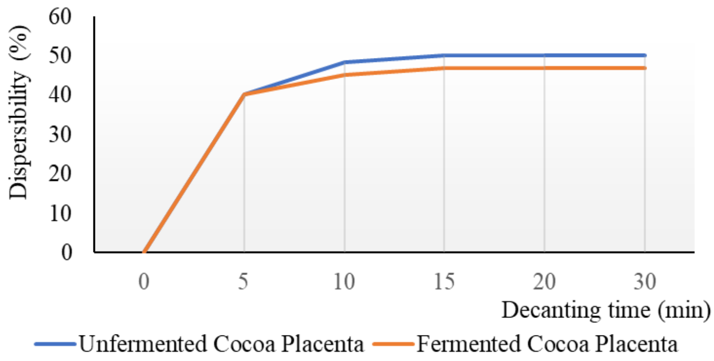

Fig.1. Dispersibility of fermented and unfermented cocoa placenta flours

4. Discussion

In order to evaluate the behavior of fermented or non-fermented cocoa placenta powders when making biscuits, the functional properties of these were determined.

The water absorption capacity value of fermented cocoa placenta powder is higher than that of unfermented placenta powder. Fermentation appears to increase the hygroscopic power of cocoa placenta powder. Indeed, the water absorption capacity depends on the affinity of flour with water. Also, water absorption capacity is an index of the maximum quantity of water that a food product would absorb and maintain. It is an essential parameter for certain product characteristics such as product wettability and starch retrogradation [29]. Fermentation is a transformation process that reduces antinutritional compounds such as tannins, phytates that chelate minerals, proteins. Fermentation thus favored their bioavailability by destruction of membrane cells and enzymatic activity [30]. Fermentation therefore releases proteins, which are therefore more apt to absorb water. The high-water absorption observed in fermented cocoa placenta powder could be due to the presence of the amino group of amino acids present in the proteins contained in this fermented placenta powder. Moreover, it could be due to the hydroxyl groups of the carbohydrates contained in the placenta powder of cocoa [31].

The work carried out by Goude et al. [11] showed that the protein content of cocoa fermented placenta (8.4%) was higher than that of unfermented placenta (5.12%). The high WAC value of the powders of cocoa placenta would be more related to their protein content than to their lipid content. This is because the availability of protein functional groups in flours is governed by the water absorption capacity which is an important property of flours used in pastry making [32]. Afoakwa [33] indicates that proteins are mainly responsible for most of the water absorption.

Regarding the water solubility index, the fermentation caused a significant decrease in this index. Indeed, from 29.55% in fresh cocoa placenta powder, this value decrease to 15.45% in fermented cocoa placenta powder. This would mean that powders or flours that have a low solubility index have an affinity with water. These powders or flours are able to disperse easily in water, giving a homogeneous solution. These results are lower than those obtained by Karim *et al*. [34] during their work on cocoa bean powder. They obtained values between 34.39 and 40.83% for the water solubility index of the beans. Also, the water solubility index obtained in this study are lower than those obtained by Diallo *et al.* [35] for seed flours of voandzou cultivars grown in Côte d'Ivoire (43-46%).

According to Mbofung *et al*. [36], the water solubility index reflects the extent of starch degradation. Proteins, sugars and lipids play an important role in this modification of the functional properties of cocoa placenta powder. The water solubility index plays an important role in the selection of flours for use in the food industry as thickeners.

The wettability value of unfermented cocoa placenta powder is higher than that of fermented powder. Fermented cocoa placenta powder dissolves in water much faster than unfermented one. Indeed, the powder from fermented placenta would have smaller, lighter and more regular surfaces than those of unfermented cocoa powder. In fact, wettability describes the ability of flour or powder particles to absorb water on their surface, thus initiating reconstitution. Wettability is the penetration of the liquid into the porous flour particles system by capillarity [37]. The effectiveness of this parameter is linked to the fact that food flours or powders from drying processes are normally reconstituted for consumption. Thus, wettability can influence the overall reconstitution characteristics of cocoa powders. A higher wettability value obtained for powder from fresh (unfermented) cocoa is an indication of the difficulties of using this powder for food formulations, including rehydration, as it will float longer on the surface of cold water [38]. The low wettability recorded for fermented cocoa placenta powder could suggest its use in food formulations, particularly in the biscuit industry.

As regards the bulk density, it is 0.69 g/mL for fresh cocoa placenta powder and 0.64 g/mL for fermented cocoa placenta powder. These values are substantially equal to the cocoa placenta powders studied. This would mean that fermentation did not significantly influence the bulk density of cocoa placenta powders. The values of bulk densities of cocoa flour grown in Lôh-djiboua and Indenie-djuablin regions (Côte d'Ivoire) (0.59 to 0.63 g/mL) are approximately equal to that of the placenta powder of fermented and non-fermented cocoa (0.64 ±0.0-0.69 g/mL) [34]. Low bulk densities obtained for cocoa placenta powders are suitable for infant food formulation [39, 40]. They are important in the feed separation process such as sedimentation, centrifugation [41]. The Bulk density is an important parameter for determining the easy ability of packaging and transportation of particulate or powdery foods [21, 42]. According to Asiedu [43], the bulk density of cocoa placenta powders is affected by their moisture content.

As for the packed density, it is higher for fermented cocoa placenta powder. Unfermented cocoa placenta powder is said to be lighter than fermented cocoa placenta powder. The fermentation process increased significantly the packed loose density.

The increase of packed density during fermentation is to be related to processing efficiency, particularly the particles size. Certainly, small particle sizes may lead to high packed densities because of better particles disposition. In the other hand, large particles size flour could lead to low packed densities with high porosity [44].

The density of flours is important in determining the packaging requirement and material handling [45].

Regarding porosity, the results showed that unfermented cocoa placenta powder (26.56%) is more porous than fermented cocoa placenta powder (20.87%).

The porosity of a flour determines the ability of a flour to be easily packaged. This parameter allows you to have a clear idea about the transport of a large quantity of food. Nutritionally, high porosity promotes the digestibility of food products, especially in children due to their immature digestive system [46].

Porosities higher than 25% may be useful in infant food formulation. Unfermented cocoa placenta powder has good porosity compared to fermented cocoa placenta powder. Flour porosity is an important factor in the food industry.

The foaming capacity of unfermented cocoa placenta powder is 11.62%. It is greater than the foaming capacity of fermented cocoa placenta which is 8.64%. According to Sathe *et al.* [47], high foam capacity is related to high protein content in flours. This decrease in the foaming capacity of fermented cocoa placenta is related to fermentation. Indeed, during fermentation, macromolecular proteins are degraded into small peptides and free amino acids under the action of microorganisms [48].

Fermentation followed by drying reduced the foaming ability of cocoa placenta powder.

Indeed, during transformation processes unit operations such as fermentation, drying and cooking have an impact on the protein level and therefore on the foaming capacity of the flour or powder. This result has already been demonstrated by Soro et al. [49] during the study on flours from fresh and boiled wild yam *Dioscorea praehensilis* Tubers. The latter obtained raw flour foam capacity of 36.92 ± 1.01% and after 40 min of cooking this value decreased to 11.79%.

Paste clarity is another important property of flour that governs which applications different flours may have for food processing. Dough clarity of unfermented cocoa powder flour (1.86%) is lower than that of fermented cocoa placenta powder dough (2.13%). Fermentation would have allowed a significant increase in the clarity of cocoa placenta paste. Indeed, unfermented (fresh) cocoa placenta powder has a darker purple color compared to fermented placenta powder which is less colored. This would mean that the less colored fermented cocoa placenta powder has a better light transmittance than that of the (more colored) unfermented cocoa placenta powder. This study suggested that this situation could be the main reason for lower paste clarity of unfermented cocoa placenta powder compared to flours from fermented cocoa placenta powder. But the intrinsic structure of starch should not be neglected too. Cross-linking of starch has been reported to reduce paste clarity in starch [50] and probably in entire flour. High paste clarity allows the application of flours and starches in confectionary and pie filling which require high clarity [51]. In this case, cooking may improve cocoa placenta flour technological potential in the food industry.

When it comes to dispersibility, unfermented cocoa placenta powder disperses faster in water than fermented cocoa placenta flour.

At a time t = 10 minutes, the unfermented cocoa placenta powder reached its maximum dispersibility (50%) while the fermented cocoa placenta powder stabilized at 46.66% at t = 15 minutes.

Dispersibility is a measure of the reconstitution of flour or starch in water, the higher the dispersibility the better the sample reconstitutes in water [52, 53] and gives a fine constituent during mixing [19]. The average value ranged from 46.66 to 50.0%. Fermented cocoa placenta powder had the lowest average value while fresh cocoa placenta powder had the highest average value. The dispersibility of these two powder samples (fermented and unfermented) is low and this probably implies that the samples will tend to form lumps during preparation. According to Compaore *et al.* [54], substances such as starch or potassium bi-carbonate (alkali) may be added to cocoa powders to prevent caking, neutralize the natural acids and astringents, with the purpose of improving its dispersibility. However, dispersibility observed for unfermented cocoa powder (fresh) hence that it will easily reconstitute to give a fine consistency to the dough during mixing compared to fermented cocoa placenta powder.

The oil absorption capacity (OAC) of cocoa placenta powder was tested using 4 different oils (refined palm oil, sunflower oil, olive oil and unrefined palm oil). The results showed that the highest OAC values were obtained with unfermented cocoa placenta powders for each oil compared to fermented cocoa placenta powders. A significant difference at the 5% threshold of the oil absorption capacity in different powders was found. The fermentation of the cocoa placenta would lead to the reduction of the OAC of the different types of powders produced. In general, the OAC decreases with fermentation.

Thus, cocoa placenta flours could be considered products with a very high OAC content. This characteristic is desired in food technology for the manufacture of preparations involving a mixture of oil such as in bakery products where oil is an important ingredient. The oil absorption capacity is high in cocoa placenta flours for the oils tested (refined palm oil, sunflower oil, olive oil and unrefined palm oil). The ability of fermented and unfermented cocoa placenta flours to bind oil makes them useful in food applications where optimal oil absorption is desired. These cocoa placenta powders would have potential functional applications in foods such as the production of pastries, sausages. According to Suresh and Samsher [55], the oil absorption capacity also makes these cocoa placenta flours suitable to facilitate flavor and mouthfeel enhancement when used in food preparation [56]. Due to these properties, flours with good OAC are used as a functional ingredient in foods such as sausages, whipped toppings, angel food cakes and sponges, chiffon desserts, etc.

The values of the hydrophilic-lipophilic ratio obtained in this study are greater than 1. This information allows us to affirm that placenta powders of cocoa, fermented or not, have more affinity for water than for the various oils studied. This suggests that our powders should be used preferably for the formulation of products requiring high water absorption capacity. However, in refined oils (olive, sunflower, palm), fermented cocoa placenta powders have a higher affinity for these oils than unfermented (fresh) placenta powder.

5. Conclusion

Fermentation has shown beneficial effects on the functional properties of cocoa placenta.

The fermentation increased the water absorption capacity, the packed density as well as the clarity of the dough. However, the water solubility index, foaming capacity, porosity and oil absorption capacity were reduced with fermentation. These aspects involve the potential use of cocoa placenta powders (fermented and unfermented) as an ingredient in baby food formulations, cakes and bread products. Finally, cocoa placenta flours (fermented and unfermented) could have multiple applications in food technology.

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