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Research Article

Effect of Local Fermentation on Sensory, Nutritional and Microbiological Quality of "Bobolo" (*Manihot esculenta Crantz*)

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Abstract

Bobolo is a thick fermented, popular traditional food, derived from cassava (*Manihot esculenta Crantz*) in Cameroon. The physical, sensory, chemical and microbiological characteristics of Bobolo were analyzed, in order to identify the suitable cassava varieties and the local fermentation method with the best nutritional and industrial properties. The range of L* (lightness / darkness), a* (redness / greenness), b* (yellowness / blueness) were 75.00±0.65-80.07±0.60, 3.7±0.57-4.90±0.60, 11.9±08-17.2±0.75 respectively. Sensorial characteristics (color, pasting, and global quality) evaluation reveal that Bobolo made with aerobic fermentation with ferment had the best characteristics and independent of varieties. The campo varieties presented superior characteristics compared to the other varieties. Bobolo of different varieties and the same processed cassava products had an average range of moisture content (40.85±0.91 – 44.36±0.33%), carbohydrates (38.72±0.66 – 40.91±1.12%), protein (1.18±0.04 – 1.44±0.01%), total fat (4.02±0.05 – 4.38±0.14%), crude fiber (1.71±0.05 – 2.77±0.15%), ash (0.28±0.05 – 0.36±0.02%) and cyanure (4.28±0.22 – 6.49±0.12mg/kg) and where they varied significantly between products and variety. The mineral analysis result in the Bobolo samples ranged 0.04±0.00 - 0.07±0.00 mg/100 g Ca, 0.07±0.00 – 0.10±0.00 mg/100 g Mg, 0.74±0.05 – 0.88±0.04 mg/100 g K, 7.82±0.87 – 11.96±1.00 mg/100 g Na, 5.7±0.14 – 8.7±0.14 ug/g Zn and 15.37±0.18-21.15±0.77 ug/g Mn respectively. The Bobolo produced contained more mesophilic total flora and molds and yeasts and was absent from *Eschericha coli*, *Staphylococcus aureus*, *Clostridium* spp. *Bacillus cereus* and *Salmonella* spp. Therefore, the types and varieties of cassava fermentations influence the quality of Bobolo.

Keywords

Manihot esculenta Crantz, Bobolo, Sensory, Physicochemical, Microbiological

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1. Introduction

Cassava (*Manihot esculenta Crantz*) is the second most crucial staple food crop in Sub-Saharan Africa (SSA) [1]. Its largest per capita use, about 800 g per person/day, is found in sub-Saharan Africa, where about 40% of the population uses it as their primary energy source [2]. With a production contribution of almost 1.6% of global output, Cameroon ranked 13th in the world in 2020 with 4,858,329 tons of cassava [3]. In 2020, cassava was cultivated on approximately 329,371 ha, yielding an average of 14.75 t/ha [3]. It is an attractive and most important crop grown in the five agro-ecological zones of Cameroon due to its high strength against pests, high tolerance to drought and acid soils, and it can grow in different ecosystems with low-nutrient soils [4, 5]. Additionally, it is anticipated that production will rise in light of the growing number of actors endorsing cassava production and the growing recognition among farmers of the significance of crop diversification for sustainable agricultural practices and food security [6, 7]. Cassava roots are a major cash crop for many households, and are either sold fresh or processed to earn money, a common practice among women for buying household items, education, health, and business investment [8].

Although, cassava has numerous advantages, its use and sale are somewhat restricted due to the brief shelf life of cassava roots, which are highly perishable above room temperature (approximately 30 ℃). Unlike yam or sweet potato, cassava doesn’t have a long shelf life once harvested and cannot be stored effectively for extended periods like other root crops [9]. In fact, the primary deterioration of cassava root known as postharvest physiological deterioration (PPD) is a physiological defense process that begins at damaged sites during harvest and spreads systematically throughout the root [10-12]. PPD symptoms begin with blue-black to black vascular discoloration (vascular streaks), which can appear 24-72 hours after harvest and induce the deterioration of most cassava varieties [13-15]. This physiological deterioration of cassava roots results in significant quantitative and qualitative losses, such as lower income for farmers and traders; threatens the continuous supply of fresh roots as raw material for industry; increases market risks within the fresh cassava value chain; and makes cassava roots unfit for consumption [16, 17]. Therefore, the prevention of PPD requires that cassava roots be consumed or processed immediately after harvest.

The processing of cassava by traditional or modern methods in different localities can be divided into two categories of products, which are nonfermented and fermented. Nonfermented products are processed to a stable or consumable form in a single step. This applies mainly to sweet cassava and to the intermediate cassava products of sweet or bitter cassava, such as dried cassava chunks, flour, and starch. Although fermented products are made by several steps of processing, this method is mainly applied to bitter-type varieties that require detoxification with cyanide [18]. Fermentation is a metabolic process that converts carbohydrates to organic acids, which is known to prevent post-harvest deterioration of roots, extend shelf life, and reduce toxicity [19]. During this process, an appreciated flavor of the product is developed, and the proliferation of lactic acid bacteria that acidifies the medium limits the proliferation of undesirable and pathogenic microorganisms [20, 21]. Some of the microorganisms involved in the natural fermentation of cassava include *Bacillus subtilis, Leuconostoc citrivorum, Streptococcus sp., Corynebacterium sp., Lactobacillus sp., Candida tropicalis* and *Geotrichum candidum* [22]. Common fermented cassava products include 'Gari', 'Fufu', 'Lafun', 'Chikwangue', and 'Bobolo', among others.

Women in households and rural processors typically handle the processing of Bobolo, with practices that can vary depending on culture and region. Fermentation plays a crucial role in the production of Baton de manioc by detoxifying the cassava pulp (i.e., degrading cyanogenic glucosides), enhancing the aroma and flavor, and aiding in preservation. The production process of Bobolo involves peeling and washing the cassava roots before cutting them into smaller pieces. Root soaking techniques vary in Cameroon depending on the region and the processors. The soaking, steeping or fermentation of the cut roots can be carried out either by continuous soaking of chunked roots for a period of 2 to 4 days of fermentation, or by dewatering, removing fibers, grinding and tied in the leaves after 48 hours of fermentation, followed by cooking.

Cassava sticks is known as *chikwangue* in the Republic of Congo, *mungbélé* in Chad, *mubangui* in the Democratic Republic of the Congo and *Bobolo* in Cameroon. ‘*Bobolo’* is one of the most popular fermented and eaten cassava-based products in Cameroon [23]. This food is becoming popular, as well as exported to other parts of the world. Unfortunately, its processing technology is characterized by empiric steps which are very difficult to control [24]. Another issue with Bobolo processing is the inconsistency in product quality between different processors and within the same processor across various processing batches. The organoleptic qualities differ between ethnic groups, producers, and production processes [25]. Traditional technologies are full of challenges with respect to the production environment, process control, and the nutritional and toxicological status of the end product [26]. There are various fermentation methods practiced in different localities and the multiplicity of products produced. Most cassava derivatives sold in our local markets still contain high levels of residual glucosides, and the hygienic quality is poor and unacceptable [27]. There is limited information on the standardization of fermentation to have a good ‘*Bobolo’*. The effect of fermentation on cyanide detoxification has probably been the main subject of study by most workers. Earlier studies on the effect of fermentation length have been concentrated on the removal of cyanogens in some cassava products [28, 29].

The purpose of this study was to stabilize the quality of cassava stick by establishing a standardized local fermentation procedure.

2. Material and Methods

2.1. Cassava Roots Used

Three (3) local cassava varieties Campo (sweet), Mitol Minko'o (better) and the improved cassava variety TMS 0326 (sweet) were harvested from Batchenga and Evodoula farms in the Lékié district. The roots were from plants 10 to 12 months old.

2.2. Production of Cassava Sticks (Baton de Manioc in French) or Bobolo (Trivial Language)

A total of forty-three (43) kg of raw cassava roots of each of the Campo, Mitol Minko'o, and TMS 0326 varieties were peeled and cut into two halves to remove the central fibres using a knife. The defibered roots were then split transversely into chunks (2 to 5 cm) and the fragments washed twice. Water used for soaking was hot to 38 °C. The chunks were soaked in water following four (4) different treatments as presented in Figure 1.

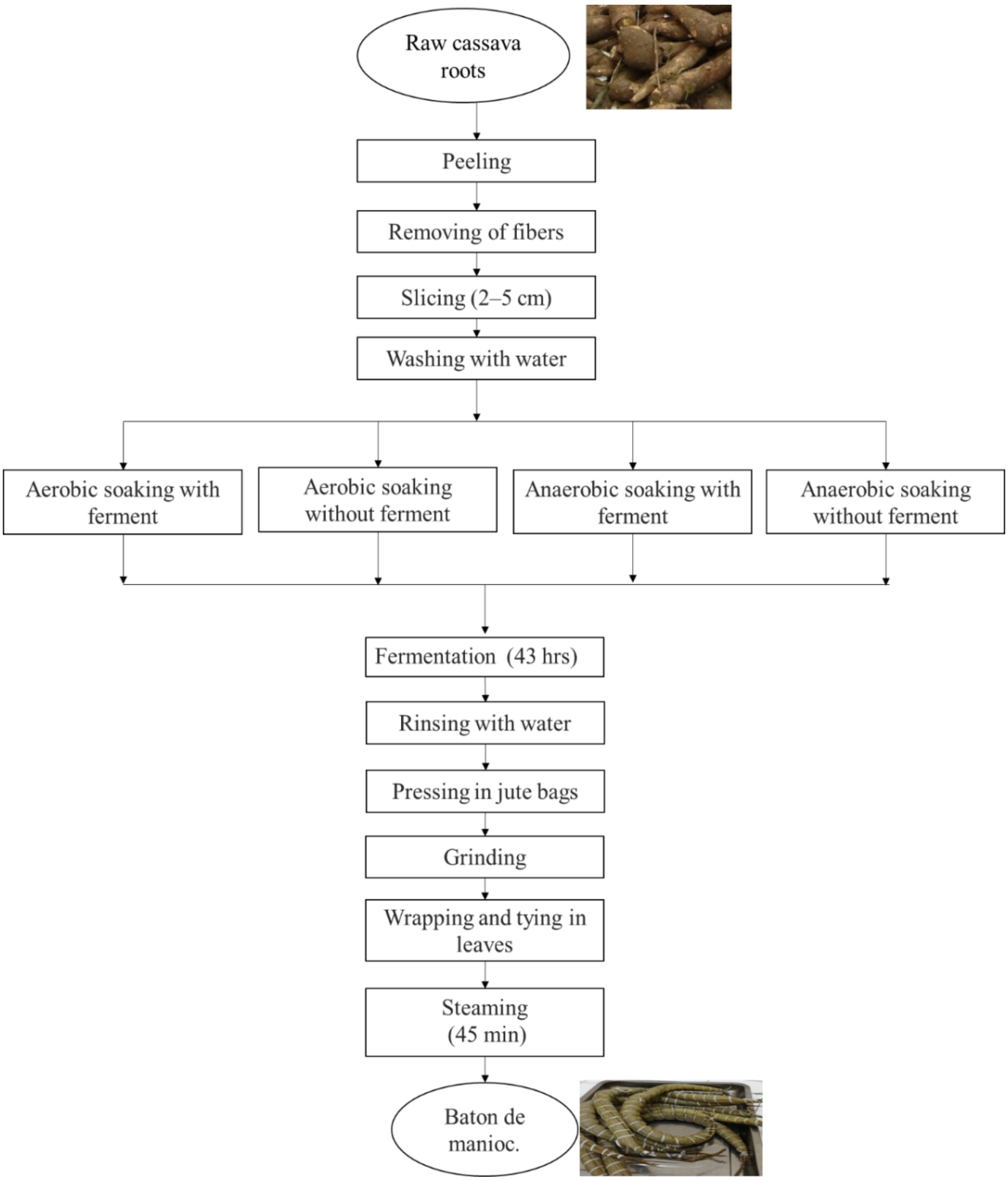

Figure 1. *Schematic diagram of Bobolo processing from cassava roots.*

2.2.1. Aerobic Fermentation with and Without Ferment

Fourteen (14) kg of peeled and washed cassava roots were divided into two parts, each three (3) varieties. One part, seven (7) kg, was soaked in tap water heated to 38 ℃ in a ratio of 1:3 w/v in a bowl, with 7.9 g of ferment (fermented cassava flour). The other part was soaked without any ferment. Both parts were soaked until softened during 43 hours at room temperature. The pieces were completely submerged in water and the bowl was uncovered to allow for exposure to air. The soft roots were removed from the soak water and rinsed with water. They were later manually mashed to remove more fibers, and the excess water was removed by pressing in jute bags. The paste was obtained after grinding the mixture in the machine, and the excess water was removed again. The small amounts of cassava paste (about 300g-320g) were then wrapped and tied in leaves (*Megaphrynium macrostachyum*) and cooked with water for about 45 min to obtain Bobolo.

2.2.2. Anaerobic Fermentation with and Without Ferment

Fourteen (14) kg of peeled and washed cassava roots were divided into two parts, each three (3) varieties. One part, seven (7) kg, was soaked in tap water heated to 38 ℃ in a ratio of 1:3 w/v in a bowl, with 7.9 g of ferment (fermented cassava flour), while the other part was soaked without any ferment. Both were tied in polyethylene bags to create anaerobic conditions and soaked until softened after a period of 43 hours at room temperature. The soft roots were removed from the soak water and rinsed with water. They were later manually mashed to remove more fibers, and the excess water was removed by pressing in jute bags. The paste was obtained after grinding the mixture in the machine, and the excess water was removed again. A given amount (300-320 g) of cassava paste was then wrapped and tied in leaves *Megaphrynium macrostachyum*) and cooked with water for about 45 min to obtain Bobolo.

2.3. Color of Raw Cassava and Its Cooked Paste

The surface color characteristics L* (lightness/darkness), a* (redness/greenness), and b* (yellowness/blueness) of the raw cassava and Bobolo were obtained with the help of a colorimeter (Color reader CR-10 JAPAN). A white calibration plate was used to standardize the equipment prior to color measurements.

2.4. Sensory Evaluation

The sensory evaluation of the cooked stick was performed with the nine-point hedonic scale method. A panel of 12 judges, composed of four men and eight women, with experience in food evaluation, aged 25 to 47 years, was formed. Samples were stick cassava with aerobic fermentation with and without ferment and anaerobic fermentation with and without ferment. Various sensory parameters include pasting, aroma, shape, color, basic flavors (sweet, salty, acidic bitter) and taste, texture (pasting, hardness, elastic, fibrous) and overall quality of cassava thick. The panelists used a nine-point rating scale to evaluate the intensity of Various sensory parameters include pasting, aroma, shape, color, basic flavors (sweet, salty, acidic bitter) and tasless, texture (pasting, hardness, elastic, fibrous) and overall quality from 0 = very unpleasant to 8 = very pleasant for the overall quality of cassava sticks according to different treatments.

2.5. Physicochemical Analysis

Moisture content was determined using the gravimetric method [30]. Total nitrogen was determined by the Kjeldahl method using 6.25 as a factor to convert total nitrogen into protein. Lipid extraction was performed using soxtec and petroleum ether as a solvent (Anon, 1990). Dietary fiber was determined by the method of Van Soest *et al.* [31] and carbohydrates were obtained by the difference method. The ash content was determined by the method of AFNOR [32], the total acidity was determined by the AFNOR method [33], and the total cyanides were determined according to the enzymatic method [34]. While the cyanide content of thick cassava was determined as reported [35]. The mineral content (K, Ca, Zn, Mg, Na, Mn, Zn) was determined by atomic absorption spectrophotometer (Varian Vista, Victoria, Autralie).

2.6. Microbiological Analysis

The evaluation of the total aerobic mesophilic flora, *Escherichia coli*, coagulase positive staphylococci, sulfite reducing anaerobes, yeasts, *Bacillus cereus*, *Salmonella* spp. were carried out according to the standards NF EN ISO 4833-2, NF ISO 16649-2, NF EN ISO 6888-2, NF V08-061, NF V08-059, NF EN ISO 7932, NF EN ISO 6579.

2.7. Statistical Analysis

Data was analyzed for normality and homogeneity of variance using Kolmogorov-Smirnov test. Data on all dependent variables were subjected to one-way analysis of variance (ANOVA) to test the effects of the different treatments as categorical predictors. Significant means was separated using Turkey's (Turkey's HSD $P < 0.05$). All analyses were done using SPSS (Version 25) for windows.

3. Results and Discussion

3.1. Color Difference

The color gives the first sensation to consumers when selecting a raw cassava. The lightness of the raw cassava L* values between 87.50±0.4 and 88.5±0.8 were recorded for the raw white-flesh varieties of the local (Mintol Minko'o) and Campo. These values were close to those reported by Adeleke *et al*. [36] for similar variants, with average L* values of 88.46±0.34–96.87±1.21 for salad creams made from different varieties of cassava starch. Ayetigbo *et al*. [37] reported L* values of 83.97–93.17 from white-flesh cassava starches. a* values of 4.7±0.2 to 5.00±0.30, and b* values of 11.10±0.20–13.7±0.5 for three white-flesh cassava roots. The white color of the inner cassava flesh is another trait for the processing of the cassava root. The preference for freshly harvested roots compared to stored ones may be related to the onset of post-harvest physiological deterioration (PPD) of roots shortly after harvest [11]. PPD is associated with certain undesirable features such as vascular streaking, root discoloration, reduction in starch quality and shelf life, increased water loss and sugar content [11, 38-41].

Colour is an important attribute of the factor that determines the quality of Bobolo. It is also one of the key quality attributes that influence the behavior, choices, and perceptions of the consumer. The chromametric color parameters ranged from 75.00±0.65 to 80.07±0.60, 3.7±0.57 to 4.90±0.60, and 11.9±0.80 to 17.2±0.75 for L*, a* and b*, respectively (Table 2), with no significant variation between varieties. The variation in the lightness of the samples may be attributed to the fermentation period. These variations can be attributed to the degradation of the color-inducing compound due to heat and oxidation during the steaming and cooking time. Bobolo is generally white or off-white depending on the processing conditions including cooking time, fermentation, and postprocessing handling. Nwabueze and Odunsi [42] found that extending fermentation could enhance the degradation of color pigments by microbes and boost the presence of reactive groups that could interact with small carbohydrates. The variations observed in the varieties indicated that the cassava variety had a substantial effect on the colour of the Bobolo. These variances could result from variations in the genetic makeup and the environment in which the plant thrived [43]. When a* is positive, the product has a reddish color; when a* is negative, the product is green [44]. The b* values are known to represent the yellowing of the roots: when b* is positive, the product is yellow; when b* is negative, the product is blue. The values were positive for cooking Bobolo, corresponding to the characteristic color of the raw cassava.

Table 1. *Color parameter of the raw white flesh variety from cassava.*

Raw			
Color parameter	**Campo**	**Mintol Minko'o**	**TMS 0326**
L*	88.5±0.80[a]	87.50±0.40[a]	87.9±0.90[a]
a*	4.7±0.20[a]	5.00±0.30[a]	4.7±0.50[a]
b*	11.5±0.43[a]	11.10±0.20[a]	13.7±0.50[a]

The mean values that do not have different superscripts within the same column are not significantly different ($p < 0.05$)

Table 2. *Color parameter of cook Bobolo from aerobic fermentation with ferment.*

Cook			
Color parameter	**Campo**	**Mintol Minko'o**	**TMS 0326**
L*	77.8±0.80[a]	80.07±0.60[a]	75.00±0.65[a]
a*	4.6±0.30[a]	4.90±0.60[a]	3.7±0.57[a]
b*	12.5±0.66[a]	17.2±0.75[a]	11.9±0.80[a]

The mean values having no different superscripts within the same column are not significantly different ($p < 0.05$)

3.2. Sensory Evaluation

The quality of Bobolo is evaluated mainly by their appearance (pasting, shape, and color), aroma, basic test, texture (pasting2, hardness, elastic, fibrous) and global quality. Sensory analyses of Bobolo made with different varieties (Campo, TMS 0326 and Mitol Minko'o) indicated that most of the sensory characteristics evaluated were positively affected by the varieties and the type of fermentation. Among them, fresh cassava roots processed by aerobic fermentation with ferment presented the highest global quality than other types of fermentation (Figure 1) and the campo variety.

Pasting is an excellent indicator of Bobolo quality when touched and is considered by consumers as a factor of good cooking. Pasting recorded 3.75-5.31 for TMS036A and Mintol Minko'o D. The lowest score of pasting refers mainly to the abundant water in the paste during processing. The components score of sensory attributes like sweetness, shape, and elastic were higher for the Campo variety than for others. Sweetness is an important characteristic of Bobolo, because this taste is due to a good pressing of the water resulting from fermentation during the processing of dough before packaging and cooking of Bobolo.

The texture of food, which includes hardness, chewiness, elasticity, and fibrousness, plays a key role in determining its sensory quality [45]. Bobolo's elasticity is a significant factor affecting consumer approval. It shows a new item created by cooking Bobolo. The findings align with the values documented in another study conducted by Nkoudou *et al.* [46]. Rosales-soto et al. [47] mentioned that the stickiness in cassava paste is linked to the interactions between molecules in the food and the inability of starch granules to release adequate amylose. This leads to a reduction in the cohesiveness of the fermented cassava product. The lack of fibrous is an important characteristic of Bobolo. Dufour *et al*. [48] reported that the presence of fiber can reduce the cohesiveness of cassava paste. Pasting 2 recorded 2.25-3.37 for TMS036D and TMS036B. These textural and pasteing characteristics of starch have been associated with the quality and texture of cooking of various food products [49]. The lowest hardness was observed for the three varieties and for different types of fermentation. This represents the characteristic of a Bobolo after cooking, ready for consumption because when it is hard it means that the cassava stick has begun to decompose. The absence of fibrous was observed in Bobolo. The reason being that almost all fibers are removed during the processing of the Bobolo. These results indicate that the Campo variety and aerobic fermentation with ferment were the most appropriate to produce the Bobolo (Figure 2).

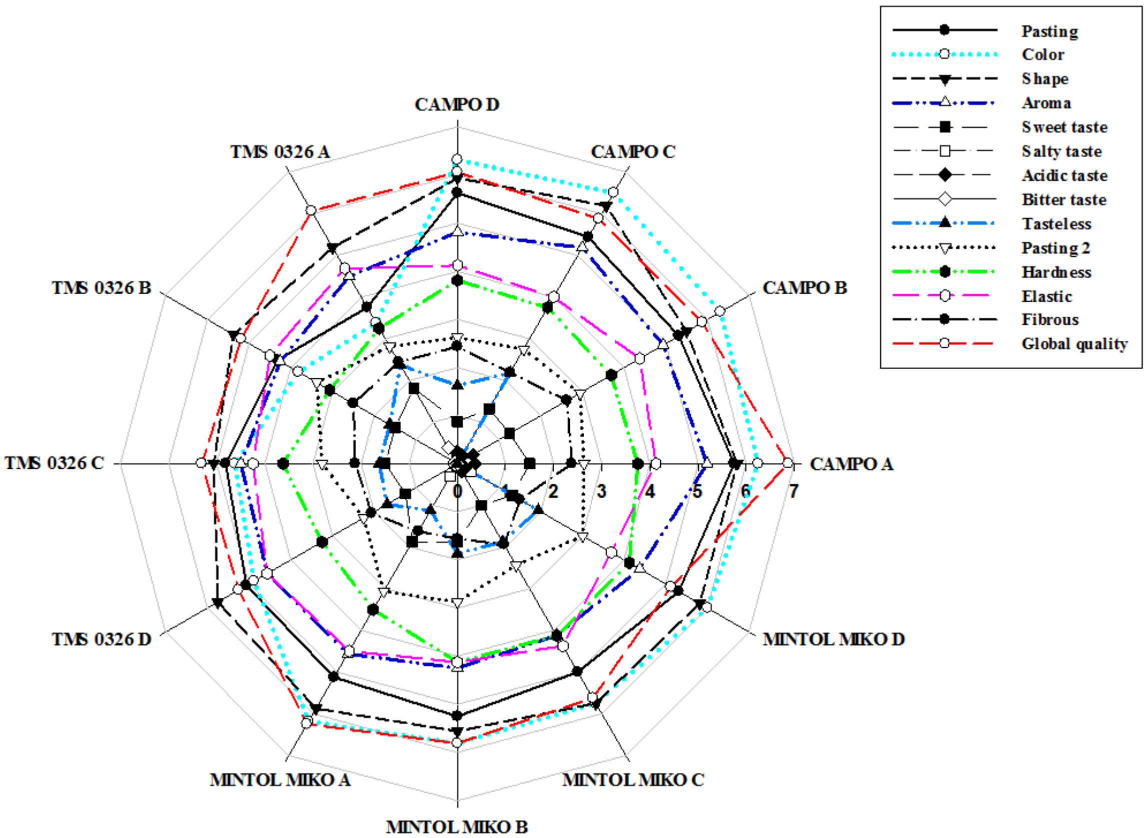

Figure 2*. Sensory properties and acceptability of aerobic and anaerobic Bobolo fermentation with fermentation and without fermentation of tree varieties of cassava.*

Campo A: Aerobic fermentation with ferment, Campo B: Aerobic without ferment, Campo C: Anaerobic with ferment, Campo D: Anaerobic without ferment

3.3. Chemical Analysis of Raw Cassava Roots and Baton de Manioc

The composition of cassava roots differs depending on cultural practices such as pruning, ratooning, age and maturity of the root at harvest, storage environment, region, and post-harvest practices. The approximate composition of the cassava varieties as shown in Table 3. The moisture content ranges from 51.33±0.12% to 59.43±0.29^{b}% with campo having the lowest value and Mintol Minko'o the highest value. Significant differences (p<0.05) existed between the varieties. The moisture results obtained in this work also agree with those presented by Rinaldi *et al.* [44] in raw cassava roots (56.97%). Bezerra *et al.* [50] highlight the importance of maintaining the moisture of cassava roots during storage, since a decrease implies favoring enzymatic reactions that culminate in vascular discoloration. Fresh cassava root, on the other hand, is very perishable due to its high moisture content (33–72%) [51, 52] and has a short post-harvest life of fewer than 72 hours. In *Bobolo*, the values are in the range (40.85±0.91 to 44.36±0.33) % were TMS 0326 has the lowest value and Mintol Minko'o the highest value (Table 4). No significant differences (p<0.05) existed between the varieties. Testing for moisture content is a common test in food, as the amount of water in food is closely linked to its preservation and the various chemical, physical, and microbiological changes that occur during storage [53].

Carbohydrate values ranged from the content of samples from campo, Mintol Minko'o, and TMS 0326 from 42.55±1.76%, 44.36±0.33% and 40.85±0.91% respectively. Mintol Minko'o has the highest value and TMS 0326 the lowest. There were no significant variations (p < 0.05) variations in carbohydrate. The carbohydrate result was higher than those of Montagnac *et al.* [54] reported that carbohydrate in fresh cassava roots had a range of 25.3% to 35.7% and 33.73 ±1.69% of carbohydrate content was reported by Somendrika *et al.* [55], while those from Bobolo ranged from (38.72 ± 0.66 to 40.91±1.12) % respectively. It appears that the fermented Bobolo still contained significant levels of starch, which is not metabolized during fermentation. Brauman [56] has showed that starch is little degraded during cassava fermentation, whereas the reducing sugars would be widely consumed. The result obtained from the Bobolo sample was higher than that reported by Bayata [57] of 21 g /100 g per dry weight.

The crude protein content of the three Mintol Minko'o varieties investigated ranged from 0.92±0.15 % to 1.41±0.03% (TMS 0326). Significant differences (p<0.05) existed between the varieties with the TMS 0326 sample recording the highest values in the regions. Manano *et al.* (2018) [58] found similar results ranging from 0.74% to 1.5%. Cassava contains very low protein levels of approximately 1–3% on a dry mass basis [59] and between 0.4 and 1.5 g of 100 g−1 fresh weight [60]. Compared to other roots and tubers, cassava roots have a low protein content of approximately 1 to 3% on dry basis [61]. The study suggests that the variation of crude protein content in cassava accessions may be due to genetic differences rather than environmental factors [62]. Cassava therefore has much less protein than cereals such as maize and sorghum, which have about 10 g of protein per 100 g of fresh weight [54]. However, those from Bololo ranged from 1.18±0.04% (Mintol Minko'o) to 1.44±0.01% (TMS 0326), respectively. This difference may be due to several factors, including the fermentation process and the difference in raw materials used. Although yeasts that play an important role during fermentation are sources of proteins, the use of fermented cassava dough for cassava sticks, as well as other cassava-derived products, contain relatively low protein content [21]. The fat content of the cassava samples ranged from 4.45±0.21% to 5.11±0.13%, with TMS 0326 having the highest value and Mintol Minko'o the lowest. This result shows that cassava roots have a low fat content. There were significant differences (p<0.05). The findings of the current study differ from those of Sarkiyayi and Agar [64], who reported high fat values (3.92% for sweet cassava varieties and 3.82% for bitter cassava varieties), while Daemo *et al.* [62] found low crude fat values for different accessions of cassava 0.26% to 1.40%. The difference in crude fat between accessions may be due to genetic differences rather than environmental factors. The fat content ranges between 4.02±0.05 and 4.38±0.14 % for the campo and TMS 0326 varities (Table 3). The fat content is low in the fermented cassava stick. These results confirm some previous work that proved that cassava roots have a low content of lipids [21, 63, 65, 66].

The fiber content of the cassava samples ranged from 1.86±0.06% to 4.87±0.07%, TMS 0326 recorded the highest crude fiber, followed by those of Campo and Mintol Minko'o. The variety and age of cassava determine its fiber content in the root. Usually, its content does not exceed 1.5% in fresh root [57]. While the Bobolo fiber content from 0.28±0.05 to 0.36±0.02 for TMS 0326 to Mintol Minko'o. The reduction of fiber is due to the removal of fibre and grinding during the process because a good Bobolo does not have fibre.

The ash content reflects the inorganic mineral content of flesh cassava. As shown in Table 3, the result obtained is low compared to 0.80±0.06 % (campo) and 1.24±0.12% (Mintol Minko'o). It generally ranges from 1% to 2%. The ash content represents the total mineral content of the food after it has been burned at a very high temperature. The ash content was lower than the values reported by other studies [67-69]. The Bobolo ash content ranges from Bobolo range from 0.80±0.06% to 1.24±0.12%. The higher content was Bobolo from Mintol Minko'o. These results were higher than those reported by Adugna [70] 0.21% of Bobolo and Chikwangue.

Cyanides were in the range 60.38±0.08 mg/kg, and varied significantly (p < 0.05) among varieties. The lowest cyanide content was recorded in the improved TMS0326, and the highest in Mintol Minko'o among the local variety varieties. The results obtained showed that the cyanide content was relatively higher in the local cultivar than in the improved one; similar results were obtained by Njankouo *et al.* [71] in different cultivars in Cameroon. Although, depending on the cassava genotype, some cultivars may have better cyanide potential than others belonging to the same group (local or improved varieties) [72]. Significant differences in cyanide content observed with the studied cultivars corroborate those reported which linked the wide variability of cyanide content in cassava roots to cultivar differences, plant growing conditions (soil type, humidity, temperature), maturity of the plant, nutritional status of the plants, prevailing seasonal and climatic conditions during harvest, as well as the impact of environmental pollution and application of inorganic fertilizers [73-75]. In another way, Ubwa *et al.* [76] reported that the cyanide content of the cultivars varied from one local government to another and also from one farm to another. The cyanide content ranged between 4.28±0.22 and 6.49±0.12 mg/kg and differed significantly ($p< 0.05$) among the varieties. The lowest cyanide content was recorded in Campo and differed significantly ($p < 0.05$) from the improved varieties. The variability in cyanide content of the final product probably depends on the cassava varieties, but it is mainly dependent on processing. Compared to cassava roots, cyanide in Bobolo was significantly reduced. The percentage of cyanide reduction in cassava ticks was 56.87, 63.01 and 55.17%, in Campo, Mintol Minko'o, and TMS0326, respectively. Agbor-Egbe and Mbome [28] showed that cassava root processing was an effective way to reduce the cyanogen content (197.3-951.25 mg / kg) to low levels (1.1–27.5 mg/kg) during the production of some Cameroonian foods (*bâton de manioc*, *fufu*, and *gari*). *Bobolo (Baton de manioc)* had cyanide contents of less than 10 mg/kg of HCN recommended safe level by WHO.

Table 3. *Proximate composition of raw flesh cassava peels from three varieties.*

Raw varieties			
Parameters	**Campo**	**Mintol Minko'o**	**TMS 0326**
Moisture content (%)	51.33±0.12[a]	59.43±0.29[b]	58.17±0.11[a]
Carbohydrate (%)	24.4±1.34[a]	27.98±0.88[b]	22.80±0.21[a]
Protein (%)	1.26±0.15[ab]	0.92±0.15[a]	1.41±0.03[b]
Fat (%)	4.77±0.22[ab]	4.45±0.21[a]	5.11±0.13[b]
Fiber (%)	3.05±0.09[b]	1.86±0.06[a]	4.87±0.07[c]
Ash (%)	0.80±0.06[a]	1.24±0.12[b]	0.83±0.04[a]
Cyanure (mg/kg)	61.15±0.07[a]	69.5±0.70[b]	60.38±0.08[a]

The values in the same column with different letters are significantly different at $p<0.05$.

Table 4. *Proximate composition of Bobolo from three varieties with aerobic fermentation with ferment.*

Baton de manioc **(Bobolo)**			
Parameters	**Campo**	**Mintol Minko'o**	**TMS 0326**
Moisture content (%)	42.55±1.76[a]	44.36±0.33[a]	40.85±0.91[a]
Carbohydrate (%)	38.72±0.66[a]	40.91±1.12[a]	40.23±0.21[a]
Protein (%)	1.42±0.04[b]	1.18±0.04[a]	1.44±0.01[b]
Fat (%)	4.02±0.05[a]	4.14±0.06[ab]	4.38±0.14[b]
Fiber (%)	2.11±0.15[b]	1.71±0,05[a]	2.77±0.15[c]
Ash (%)	0.30±0.00[a]	0.36±0.02[a]	0.28±0.05[a]
Cyanure (mg/kg)	4.28±0.22[a]	6.49±0.12[c]	5.21±0.16[b]

Values in the same column with different letters are significantly different at $p<0.05$.

The concentrations of minerals in different varieties of cassava analyzed are presented in Table 5. The calcium content ranged from 0.045±0.00 to 0.075±0.00 mg/100 g with raw cassava being the highest in the Mintol Minko'o varities. The Ca concentration obtained from the raw cassava sample in this study was lower than 40.96±0.99 mg/100 g of fresh weight (and 20 mg/100 g of fresh weight as reported by Bradbury [77]. The values obtained for Bobolo (0.025±0.00 and 0.04±0.00 mg/100 g) were lower than the reported value of 7 mg/100 g. Calcium plays an important role in increasing cell membrane permeability and in the transmission of nerve impulses. 800 g of calcium is recommended per day for an adult person [64].

Magnesium ranged from 0.07±0.00 to 0.10±0.01 mg/100 g with raw cassava was the highest in the TMS 0326 varieties. However, all samples were significantly different (p<0.05) in their Mg content. Raw sample values obtained for magnesium content were lower compared to those reported by Adepoju *et al.* [78] of 12.5 mg/100 g. The magnesium content in cassava and fermentable foods is reduced with the fermentation period [79]. The Bobolo value range from 0.04±0.00 to .07±0.00 mg/100 g Mintol Minko'o was higher. The result showed that all samples were significantly different (p<0.05). The recommended dietary allowance (RDA) per day for magnesium is 240 mg.

Potassium (K) ranged from 0.74±0.05 to 0.88±0.04 mg/100 g with Campo varieties being the highest while TMS O326 was the lowest. The result showed that all samples were significantly different (p>0.05). The raw cassava results are not in agreement with the reported value of 309.4 mg/100 g [78]. The result obtained from the raw sample was lower than that reported by Charles *et al.* [59] of 324 to 554 mg /100 g of dry weight. Potassium (K) ranged from 0.1 ± 0.02^a to 0.3 ± 0.00^c Bobolo from Mintol Minko'o being the highest, while Bobolo from TMS 0326 was the lowest (Table 6). The recommended dietary allowance (RDA) per day for potassium is 4500 mg.

Sodium ranged from 7.82±0.87 to 11.96±1.00 mg/100 g with Mintol Minko'o varieties being the highest. Samples were significantly different at (p<0.05). The sodium content obtained for raw cassava of 11.96±1.00 mg/100 g was lower than that reported by 20.06 mg / 100 g of fresh weight [80] and higher than 7.6 mg/100 g as reported by Buitrago [61]. The Bobolo value ranges from 6.81 ± 1.31^a to 7.33±0.15 mg/100g. The daily sodium dietary requirement per adult is 1500 mg.

The zinc content ranged from 5.7±0.14 to 8.7±0.14 ug/g. All samples were significantly different at p < 0.05. The reported value of Zn of 8.7±0.14 ug/g for raw cassava was the same compared to the obtained value of 5.6 ug/g of new released varieties of cassava (98/0581) harvested one year after planting [73]. The value of Bobolo ranged from 3.6 0.14 to 3.6±0.14 to 6.35±0.21 ug/g. The recommended dietary allowance (RDA) per day for Zn is 8 mg. Boiling has also been implicated in losses of certain micronutrients in plantain, including zinc [81].

Manganese values ranged from 17.35±0.16 to 22.65±0.21 ug/g. All samples showed significant differences at p<0.05. These results were lower than those reported by Adeniji *et al.* [73], 28.1 ug/g from TMS97/2205 and 32.3 ug/g from TME419. The Bobolo ranges from 15.37±0.18 to 21.15±0.77 ug/g. 1.9 mg/day is recommended for adequate manganese intake.

Table 5. *Minerals composition of raw flesh cassava peels from three varieties.*

Raw varities			
Parameters	**Campo**	**Mintol Minko'o**	**TMS 0326**
Ca (mg/100 g)	0.04 ± 0.00^a	0.07 ± 0.00^c	0.05 ± 0.01^b
Mg (mg/100 g)	0.07 ± 0.00^a	0.09 ± 0.00^b	0.10 ± 0.01^b
K (mg/100 g)	0.88 ± 0.04^b	0.75 ± 0.07^a	0.74 ± 0.05^a
Na (mg/100 g)	7.82 ± 0.87^a	11.96 ± 1.00^c	9.76 ± 0.14^b
Zn (ug/g)	5.7 ± 0.14^a	8.7 ± 0.14^c	7.75 ± 0.21^b
Mn (ug/g)	20.85 ± 0.49^b	22.65 ± 0.21^c	17.35 ± 0.16^a

Values in the same column with different letters are significantly different at p<0.05.

Table 6. *Bobolo mineral composition of Bobolo from three varieties.*

***Baton de manioc* (Bobolo)**			
Parameters	**Campo**	**Mintol Minko'o**	**TMS 0326**
Ca (mg/100 g)	42.55 ± 1.76^a	44.36 ± 0.33^a	40.85 ± 0.91^a
Mg (mg/100 g)	38.72 ± 0.66^a	40.91 ± 1.12^a	40.23 ± 0.21^a
K (mg/100 g)	1.42 ± 0.04^b	1.18 ± 0.04^a	1.44 ± 0.01^b
Na (mg/100 g)	4.02 ± 0.05^a	4.14 ± 0.06^{ab}	4.38 ± 0.14^b
Zn (ug/g)	2.11 ± 0.15^b	$1.71\pm0,05^a$	2.77 ± 0.15^c
Mn (ug/g)	4.28 ± 0.22^a	6.49 ± 0.12^c	5.21 ± 0.16^b

Values in the same column with different letters are significantly different at p<0.05.

3.4. Microbiological Aspect of Bobolo with Aerobic Fermentation with Ferment

The results of the microbiological analysis of the Cameroon cassava stick are presented in Table 7. The number of total aerobic mesophilic florea (TAMF) ranges between NE400 and >3000000ufc/g of Mintol Minko'o and Campo produced with aerobic fermentation with ferment. High total aerobic mesophylic flora may indicate a lack of hygiene-sanitary conditions during fermentation, but according to Carvalho *et al.* [82], they may also represent total microbial flora, since the culture medium used (PCA) allows for the growth of several microorganisms. The fermentation of raw cassava to produce Bobolo is traditionally carried out using the natural microbial fauna present in the cassava starch. This Microbial Flora consists mainly of lactic, homofermentative and heterofermentative bacteria with a predominance of Lactobacillus plantarum [83]. The number of yeasts and molds present in Bobolo can range from under 400 to 30,000 CFU/g. These findings are notably less than the studies by Assanvo *et al.* [84] and Flibert *et al.* [21], which reported around 7.0 log CFU/g of dough. Brauman [56] states that yeasts, particularly Candida spp., have minimal impact on submerged cassava fermentation, but may affect the preservation of cassava dough. Furthermore, yeasts are responsible for the production of volatile compound [66] that influence the organoleptic quality of cassava stick. *Escherichia coli*, *Staphylococcus aureus*, and *Clostridium spp* are less represented; the complete samples have less than 10 coliform/g. *Salmonella* bacteria were absent in all samples analyzed. Following these results, it can be concluded that the sanitation systems and hygienic practices of the cassava stick production are respected in production. All the Bobolo samples showed the absence of *Bacillus cereus*, these results were within the limits established by the regulation [85].

Table 7. *Microbiological analyses of cooked baton de manioc.*

Microorganisms							
Sample	**Mesophilic aerobic total flora**	**Eschericha coli**	**Staphylococcus aureus**	**Clostridium spp**	**Molds and yeasts**	**Bacillus cereus**	**Salmonella spp**
Mitol Minko'o	NE400	<10 ufc/g	<10 ufc/g	<10 ufc/g	400 ufc/g	<100ufc/g	Absent
Campo	>3000000 ufc/g	<10 ufc/g	<10 ufc/g	<10 ufc/g	30000ufc/g	<100ufc/g	Absent
TMS 0326	13000 ufc/g	<10 ufc/g	<10 ufc/g	<10 ufc/g	1400 ufc/g	<100ufc/g	Absent

4. Conclusion

In this study, different cassava varieties were investigated to standardize local fermentation and thus allow stabilization of the quality of the baton de manioc. The quality and the acceptability of Bobolo differed from the cassava variety, as well as aerobic fermentation with and without ferment and anaerobic fermentation with and without ferment. Bobolo processed from aerobic fermentation with ferment with the cassava variety Campo was the best in terms of overall quality, color, and cyanure content. That is the most appreciable Bobolo obtained after aerobic fermentation with ferment of cassava roots for 43 h.

Abbreviations

AFNOR	*Association Fran çaise de Normalisation*
Ca	Calcium
HCN	Hydrogen Cyanide
K	Potassium
Mg	Manesium
Mn	Manganese
Na	Sodium
PPD	Postharvest Physiological Deterioration
RDA	Recommended Dietary Allowance
TMS	Tropical Manihot Selection
WHO	World Health Organization
Zn	Zinc

Author Contributions

EFE: conceptualization, Methodology, formal analysis & writing–original draft. JEGM, HTM, TEN, BZZ: Methodology, formal analysis. MBLA, WFB: Conceptualization, Methodology, Project administration, review and editing. All the authors read and approved the final version of the manuscript.

Data Availability Statement

The data is available from the corresponding author upon reasonable request.

Conflicts of Interest

The authors declare no conflicts of interests.

References

[1] Katz, SH., Weaver, WW. (2020). Cassava, in: Encyclopedia of Food and Culture, Schribner, New York, ISBN 0684805685, https://www.newworldencyclopedia.org/p/index.php?title=Cassava&oldid=1030031

[2] Burns, A., Gleadow R., Cliff, J., Zacarias, A., Cavagnaro, T. (2010). Cassava: the drought, war and famine crop in a changing world, Sustainability 2(11) 3572–3607. https://doi.org/10.3390/su2113572

[3] FAOSTAT, 2020. FAO. Online statistical database: food balance. http://fao.org/faostat/fr/#data/QCL/vivualiz

[4] Essono, G., Ayodele, M., Foko, J., Akoa, A., Gockowski, J., Ambang, Z., Bell, J. M., Bekolo, N. (2008). Farmers' perceptions of practices and constraints in cassava (Manihot esculenta Crantz) chips production in rural Cameroon, *African Journal of Biotechnology*, 7(22): 4172-4180.

[5] Moreno, FL., Parra-Coronado, A., Camachotamayo, JH. (2014). Mathematical Simulation Parameters for Drying of Cassava Starch Pellets, *Eng. Agríc. Jaboticabal*, 34(6): 1234-1244.

[6] Masamba, K., Changadeya, W., Ntawuruhunga, P., Pankomera, P., Mbewe, W., Chipungu, F. (2022). Exploring Farmers' Knowledge and Approaches for Reducing Post-Harvest Physiological Deterioration of Cassava Roots in Malawi. Sustainability, 14, 2719. https://doi.org/10.3390/su14052719

[7] Mbassi, JEG., Mapiemfu-Lamare, D., Eyenga, EF., Ngome A. F., (2018). Duration of freezing influences sensory attributes of cassava (*Manihot esculenta Crantz*) and plantain *(Musa paradisiaca AAB)*. J. Food Technol. Res., 2018, 5(1): 19-27. https://doi.org/10.18488/journal.58.2018.51.19.27

[8] Njukwe, E., Onadipe, O., Thierno, DA., Hanna, R., Kirscht, H., Maziya-Dixon, B., Araki, S., Mbairanodji A., Ngue-Bissa. T. (2014). Cassava processing among small-holder farmers in Cameroon: Opportunities and challenges. *International Journal of Agricultural Policy and Research*, 2(4): 113-124.

[9] Salcedo, A.; Valle, A. D.; Sanchez, B.; Ocasio, V.; Ortiz, A.; Marquez, P.; Siritunga, D. (2010). Comparative Evaluation of Physiological Post-Harvest Root Deterioration of 25 Cassava (Manihot Esculenta) Accessions: Visual vs. Hydroxycoumarins Fluorescent Accumulation Analysis. Afr. J. Agric. Res., 5, 3138–3144.

[10] Onyenwoke, C. A., Simonyan, K. J. (2014). Cassava Post-Harvest Processing and Storage in Nigeria: A Review. Afr. J. Agric. Res. 9, 3853–3863. https://doi.org/10.5897/AJAR2013.8261

[11] Zainuddin, IM., Fathoni, A., Sudarmonowati, E., Beeching, J. R., Gruissem, W., Vanderschuren, H. (2018). Cassava post-harvest physiological deterioration: from triggers to symptoms. Postharvest Biology and Technology. 142, 115-123. https://doi.org/10.1016/j.postharvbio.2017.09.004

[12] Luna, J., Dufour, D., Tran, T., Pizarro, M., Calle, F., Domínguez, M. G., Hurtado, I. M., Sánchez, T., Ceballos, H. (2020). Post-harvest physiological deterioration in several cassava genotypes over sequential harvests and effect of pruning prior to harvest. Int. J. Food Sci. Technol., 56, 1322–1332. https://doi.org/10.1111/ijfs.14711

[13] Iyer, S., Mattinson, D. S., Fellman, J. K. (2010). Study of the Early Events Leading to Cassava Root Postharvest Deterioration. Trop. Plant Biol., 3, 151–165. https://doi.org/10.1007/s12042-010-9052-3

[14] Morante, N., Sánchez, T., Ceballos, H., Calle, F., Perez, J. C., Egesi, C., Cuambe, C. E., Escobar, A. F., Ortiz, D., Chavez, A. L. et al. (2010). Tolerance to Postharvest Physiological Deterioration in Cassava Roots. Crop. Sci., 50, 1333–1338. https://doi.org/10.2135/cropsci2009.11.0666

[15] Ndjouenkeu, R. (2018), Cassava in Central and Western Africa: Postharvest Constraints and Prospects for Research and Market Development. In Cassava; InTech: London, UK, 199–217. http://dx.doi.org/10.5772/intechopen.71507

[16] Mlingi, N. V., Ndunguru, G. T. (2003). A Review of Post-Harvest Activities for Cassava in Tanzania. In Proceedings of the 13th ISTRC Symposium, Arusha, Tanzania; 2007: 506–513.

[17] Salcedo, A. (2011). Insights into the Physiological, Biochemical and Molecular Basis of Postharvest Deterioration in Cassava (Manihot esculenta) Roots. Am. J. Exp. Agric., 1: 414–431.

[18] Bechoff, A. (2017). Use and nutritional value of cassava roots and leaves as a traditional food. Burleigh Dodds Science Publishing Limited. http://dx.doi.org/10.19103/AS.2016.0014.01

[19] Flibert, G., Tankoano, A., Savadogo, A. (2016a). African cassava Traditional Fermented Food: The Microorganism's Contribution to their Nutritional and Safety Values-A Review. International Journal of Current Microbiology and Applied Sciences, 5(10): 664-687.

[20] Anyogu, B., Awamaria, JP., Sutherland, L,. Ouoba, II. (2014). Molecular characterisation and antimicrobial activity of bacteria associated with submerged lactic acid cassava fermentation. Food Control, 39: 119-127. https://doi.org/10.1016/j.foodcont.2013.11.005

[21] Flibert, G., Donatien, K., Hagrétou, S. L. (2016b). Hygienic Quality and Nutritional Value of Attiéké from Local and Imported Cassava Dough Produced with Different Traditional Starters in Burkina Faso. Food and Nutrition Sciences, 7, 555-565. https://doi.org/10.4236/fns.2016.77057

[22] Oyewole, O., Isah, P. (2012). Locally fermented foods in Nigeria and their significance to national economy: a review. Journal of Recent Advances in Agriculture, 1, 92–102. https://doi.org/10.4236/aim.2020.109037

[23] Fonji, F. T., Temegne, CN., Ngome, F. A. (2017). Quantitative Analysis of Cassava Products and Their Impacts on the Livelihood of Value Chain Actors: Case of the Centre Region of Cameroon. *Annual Research & Review in Biology*, *15*(6), 1–14. https://doi.org/10.9734/ARRB/2017/34163

[24] Moorthy S. N., Mathew, G. (1998). Cassava Fermentation and Associated Changes in Physicochemical and Functional Properties, Critical Reviews in Food Science and Nutrition, 38: 2, 73-121. https://doi.org/10.1080/10408699891274174

[25] Djouldé D. R., Etoa F-X., Essia N. J-J., Mbofung C. M. F. (2003). Fermentation du manioc cyanogène par une culture mixte de *Lactobacillus plantarum et Rhizopus Oryzae*. Microb. Hyg. Ali. 15(44): 9–13.

[26] Falade, KO., Akingbala, JO. (2010). Utilization of Cassava for Food. Food Reviews International, 27(1), 51-83. https://doi.org/10.1080/87559129.2010.518296

[27] Djoulde, DR., Essia, NJ-J., Etoa F-X. (2007). Nutritive Value, Toxicological and Hygienic Quality of Some Cassava Based Products Consumed in Cameroon. Pakistan Journal of Nutrition 6(4): 404-408. https://doi.org/10.3923/pjn.2007.404.408

[28] Agbor, ET., Lape, MI., (2006). The effects of processing techniques in reducing cyanogen levels during the production of some Cameroonian cassava foods. Journal of Food Composition and Analysis 19, 354–363. https://doi.org/10.1016/j.jfca.2005.02.004

[29] Oyewole, OB., Ogundele, SL. (2001). Effect of length of fermentation on the functional characteristics of fermented cassava 'fufu'. The Journal of Food Technology in Africa, 6(2), 38-40. https://doi.org/10.4314/jfta.v6i2.19283

[30] Künsch, U., Schärer, H., Patrian, B., Hurter, J., Conedera, M., Sassella, A., Jelmini, G. (1999). Quality assessment of chestnut fruits. Acta Horticulturae 494, 119–122. https://doi.org/10.17660/ActaHortic.1999.494.17

[31] Van, S. P., Robertson, J., Lewis, B. (1991). Methods for dietary fiber, detergent fiber, and 456 non-starch polysaccharides in relation to animal nutrition. J. Dairy Sci, 74: 3583-3597. https://doi.org/10.3168/jds.S0022-0302(91)78551-2

[32] AFNOR: Association Française de Normalisation (1995). NFT 60–2201995; détermination de l'indice de péroxyde. Association Française de Normalisation, Paris, France.

[33] AFNOR (Association Francaise de Normalisation) (1982) Recueil des normes francaises des produits dérivés des fruits et légumes. Jus de fruits, Paris, 327 pages.

[34] Ikédiobi, CO., Onyia, GOC., Eluwa CE. (1980). A rapid and inexpensive assay for total Cyanid in Cassava (*Manihot esculenta Crantz*) and cassava Products, Agr. biol. chem., 44, 2803-2809. https://doi.org/10.9734/IJBCRR/2017/37522

[35] Nkoudou, NZ., Essia, JJN. (2017). Cyanides reduction and pasting properties of cassava (Manihot esculenta Crantz) flour as affected by fermentation process. Food and Nutrition, 8, 326–333. https://doi.org/10.4236/fns.2017.83022

[36] Adeleke, DM., Shittu, TA., Abass, AB., Awoyale W., Awonorin, SO., Eromosele, CO. (2020). Physicochemical properties, rheology, and storage stability of salad creams made from different cassava starch varieties. J Food Process Preserv.; 00: e14662. https://doi.org/10.1111/jfpp.1466

[37] Oluwatoyin, A., Sajid, L., Adebayo, A., Müller, JID. (2018). Comparing Characteristics of Root, Flour and Starch of Biofortified Yellow-Flesh and White-Flesh Cassava Variants, and Sustainability Considerations: A Review. Sustainability, 10, 3089. https://doi.org/10.3390/su10093098

[38] Opara, UL. (1999). Cassava storage. CIGR Handbook of Agricultural Engineering Agro. St. Joseph, MI, American Society of Agricultural Engineers. IV.

[39] Opara, UL. (2009). Postharvest technology of root and tuber crops. In: R. Dris, R. Niskanen & S. M. Jain (Eds.), Crop management and post-harvest handling of horticultural product. Science publishers Inc. 382-406. https://doi.org/10.1007/s11947-015-1478-z

[40] Buschmann, H., Reilly, K., Rodriguez, MX., Tohme, J., Beeching, JR. (2000). Hydrogen peroxide and flavan-3-ols in storage roots of cassava (Manihot esculenta Crantz) during postharvest deterioration. J. Agr. Food Chem., 48, 5522-5529. https://doi.org/10.1021/jf000513p

[41] Sánchez, T., Chavez, A. L., Ceballos, H., Rodriguez-Amaya, D. B., Nestel, P., Ishitani, M. (2006). Reduction or delay of post-harvest physiological deterioration in cassava roots with higher carotenoid content. Journal of the Science of Food and Agriculture 86(4): 634-639. https://doi.org/10.1002/jsfa.2371

[42] Nwabueze, T., Odunsi, F. (2007). Optimization of process conditions for cassava (Manihot esculenta) lafun production. African Journal of Biotechnology, 6(5), 603–611.

[43] Onitilo, MO., Sanni, LO., Daniel, I., Maziya-Dixon, B., Dixon, A. (2007). Physicochemical and functional properties of native starches from cassava varieties in Southwest Nigeria. Journal of Food Agriculture and Environment, 5(34), 108-114. https://hdl.handle.net/10568/92196

[44] Rinaldi, MM., Vieira, AE., Fialho, JF. (2019). Postharvest conservation of minimally processed cassava roots subjected to different packaging systems. Jaboticabal 47(2), 144–155. https://doi.org/10.15361/1984-5529.2019v47n2p144-155

[45] Peleg, G. M. (1987). Physical measures of texture. Food Texture. New York.

[46] Nkoudou, NZ., Engama, MMJ., Essia, NJJ. (2021). New retting method of cassava roots improve sensory attributes of Bobolo and Chikwangue in Central Africa: An approach through just about right (JAR) test. Emirates Journal of Food and Agriculture. 33(6): 475-482. https://doi.org/10.9755/ejfa.2021.v33.i6.2716

[47] Rosales-soto, MU., Ross, CF., Younce, F., Fellman, JK., Mattinson SD., Huber K., Powers, JR. (2016). Physico-chemical and sensory evaluation of cooked fermented protein fortified cassava (manihot esculenta crantz) flour. Advances in Food Technology and Nutritional Sciences Open Journal, 2(1), 9-18. https://doi.org/10.17140/AFTNSOJ-2-126

[48] Dufour, D., O' Brein, GM., Best, R. (2002). Cassava flour and starch: progress in research and development. International Center for Tropical Agriculture (CIAT), Apartado Aereo 6713, Cali, Colombia.

[49] Otegbayo,. B., Aina,. J., Asiedu,. R., Bokanga, M. (2006). Pasting characteristics of fresh yams (Dioscorea spp.) as indicators of textural quality in a major food product- – pounded yam. Food Chemistry, 99, 663–669. https://doi.org/10.1016/j.foodchem.2005.08.041

[50] Bezerra, VL., Pereira, RGFA., Carvalho, VD., Vilela, ER. (2002). Raízes de mandioca minimamente processadas: efeito do branqueamento na qualidade e na conservação. Ciência e Agrotecnologia 26(3): 564-557.

[51] Agiriga, A., Iwe, M. (2016). Optimization of chemical properties of cassava varieties harvested at different times using response surface methodology. American Journal of Advanced Food Science and Technology 4, 10–21. https://doi.org/10.7726/ajafst.2016.1002

[52] Nyirendah, DB., Afoakwa, EO., Asiedu, C., Budu A.S., Karltun, CL. (2012). Chemical composition and cyanogenic potential of traditional and high yielding CMD resistant cassava (Manihot esculenta Crantz) varieties. International Food Research Journal, 19(1), 175–181.

[53] Zambranoa, MV., Baishali, D., Mercer, DG., MacLean, HL., Touchie, MF. (2019). Assessment of moisture content measurement methods of dried food products in small-scale operations in developing countries: A review. Trends in Food Science & Technology 88 484–496. https://doi.org/10.1016/j.tifs.2019.04.006

[54] Montagnac, JA., Davis, CR., Tanumihardjo, SA. (2009). Nutritional Value of Cassava for use as a Staple Food and Recent Advances for Improvement. Comprehensive Review in Food Science and Food Safety, 8(3), 181–188. https://doi.org/10.1111/j.1541-4337.2009.00077.x

[55] Somendrika, MAD., Wickramasinghe, I., Wansapala, MAJ., Peiris S. (2016). Analyzing Proximate Composition of Macro Nutrients of Sri Lankan Cassava Variety "Kirikawadi". Pakistan Journal of Nutrition, 15(3): 283-287. https://doi.org/10.3923/pjn.2016.283.287

[56] Brauman, A., Keleke, S., Malonga, M., Miambi, E., Ampe, F. (1996), Microbiological characterization of cassava retting a traditional lactic acid fermentation for foo-foo (cassava flour) production. Applied and Environmental Microbiology. 62: 2854–2858. https://doi.org/10.1128/aem.62.8.2854-2858.1996

[57] Bayata, A. (2019). Review on Nutritional Value of Cassava for Use as a Staple Food. Science Journal of Analytical Chemistry. 7(4), 83-91. https://doi.org/10.11648/j.sjac.20190704.12

[58] Manano, J., Ogwok, P., Byarugababazirake GW. (2018). Chemical composition of major cassava varieties in Uganda. Targeted for Industrialisation, 7(1), 1–9. https://doi.org/10.5539/jfr.v7n1p1

[59] Charles, A. L., Sriroth, K., Huang, TC. (2005). Proximate composition, mineral contents, hydrogen cyanide and phytic acid of 5 cassava genotypes. Food Chem. 92, 615–620. https://doi.org/10.1016/j.foodchem.2004.08.024

[60] Bradbury, JH., Holloway, WD. (1988). Chemistry of Tropical Root Crops: Significance for Nutrition and Agriculture in the Pacific; Australian Centre for International Agricultural Research: Canberra, Australia, 76–104.

[61] Buitrago, JA. (1990). *La Yucca en la Alimentacion Animal;* Centro Internacional de Agricultura Tropical: Cali, Colombia.

[62] Daemo, BB., Yohannes, DB, Beyene, TM., Abtew, WG. (2022). Biochemical Analysis of Cassava (Manihot esculenta Crantz) Accessions in Southwest of Ethiopia. Journal of Food Quality, 9904103, https://doi.org/10.1155/2022/9904103

[63] Mehouenou, FM., Dassou, A., Sanoussi, F., Dansi, A., Adjatin, A., Dansi, M., Assogba, P., Ahissou H. (2006). Physicochemical characterization of cassava (Manihot esculenta cruntz) elite cultivar of southern Benin. International Journal of Advanced Research in Biological Sciences, 3(3): 190-199. http://s-o-i.org/1.15/ijarbs-2016-3-3-24

[64] Sarkiyayi, S., Agar, TM. (2010). Comparative analysis on the nutritional and antinutritional contents of the sweet and bitter cassava varieties. Advance Journal of Food Science and Technology 2(6): 328-334. https://doi.org/10.12691/ajfst-6-3-1

[65] Ihekoronye, AI., Ngoddy, PO. (1985). Tropical fruits and vegetables. Integrated Food Science and Technology for the Tropics, 293-311.

[66] Lasekan, O., Hosnas, R., Siew, NG., Mee, L., Azeez, S., Li T., Gholivand, S., Shittu, R. (2016), Identification of aromatic compounds and their sensory characteristics in cassava flakes and "garri" (Manihot esculenta Crantz). CyTA - Journal of Food 14(1): 154–161. https://doi.org/10.1080/19476337.2015.1074944

[67] Otache, MA., Ubwa, ST., Godwin, AK. (2017). Proximate anlysis and mineral composition of peels of three sweet cassava cultivars. Asian J. Phys. Chem. Sci., 3, 1–10. https://doi.org/10.9734/AJOPACS/2017/36502

[68] Idugboe, OD., Nwokoro, SO., Imasuen, JA. (2015). Chemical composition of cassava peels collected from four locations (Koko, Warri, Okada and Benin City), Brewers' spent yeast and three grades os caspeyeast. Int. J. Sci. Res., 6, 1439–1442. https://doi.org/10.21275/ART20172389

[69] Peprah. BB., Parkes, EY., Harrison, OA., van Biljon, A., Steiner-Asiedu M., Labuschagne, MT. (2020). Proximate Composition, Cyanide Content, and Carotenoid Retention after Boiling of Provitamin A-Rich Cassava Grown in Ghana. Foods 9, 1800; https://doi.org/10.3390/foods9121800

[70] Adugna, M., Ketema, M., Goshu, D., Debebe, S. (2019). Market outlet choice decision and its effect on income and productivity of smallholder vegetable producers in Lake Tana basin, Ethiopia. Review of Agricultural and Applied Economics 22(1) 83-90. https://doi.org/10.15414/raae.2019.22.01.83-90

[71] Njankouo, NN., Mounjouenpou, P., Kansci, G., Kenfack, MJ., Meguia MPF., Ngono, ENSN., Akhobakohb MM., Nyegue MA. (2019). Influence of cultivars and processing methods on the cyanide contents of cassava (Manihot esculenta Crantz) and its traditional food products. Scientific African 5, e00119. https://doi.org/10.1016/j.sciaf.2019.e001192468-2276

[72] Chotineeranat, S., Suwansichon, T., Chompreeda, P., Piyachomkwan, K., Vichukit, V., Sriroth, K., Haruthaithanasan, V. (2006). Effect of Root Ages on the Quality of Low Cyanide Cassava Flour from Kasetsart 50. Kasetsart J. (Nat. Sci.) 40: 694-701(2006).

[73] Adeniji, TA. (2013). Review of Cassava and Wheat Flour Composite in Bread Making: Prospects for Industrial Application. The African Journal of Plant Science and Biotechnology, 7, 1–8.

[74] Faezah, ON., Aishah, SH., Kalsom, UY. (2013). Comparative evaluation of organic and inorganic fertilizers on total phenolic, total flavonoid, antioxidant activity and cyanogenic glycosides in cassava (Manihot esculenta), Afr. J. Biotechnol., 12(18) 2414–2421.

[75] Siritunga, D., Sayre, RT. (2003). Generation of cyanogen-free transgenic cassava. Planta, 217: 367–373. https://doi.org/10.1007/s00425-003-1005-8

[76] Ubwa, ST., Otache, MA., Igbum, GO., Shambe, TS. (2015). Determination of Cyanide Content in Three Sweet Cassava Cultivars in Three Local Government Areas of Benue State, Nigeria. Food and Nutrition Sciences, 6, 1078-1085. https://doi.org/10.4236/fns.2015.612112

[77] Bradbury, JH. (2004). Processing of cassava to reduce cyanide content. Cassava Cyanide Disease. Network News (CCDN), 3: 3-4. 1.

[78] Adepoju, OT., Adekola, YG., Mustapha, SO., Ogunolan, SI. (2010). Effect of processing methods on nutrient retention and contribution of cassava to nutrient intake of Nigerian consumers. Afr. J. Food Agric. Nutr. Dev., 10(2): 2099-2111. https://doi.org/10.4314/ajfand.v10i2.53353

[79] Adewusi, SRA., Ojumu, TV., Falade, OS. (1999). The effect of processing on total organic acids content and mineral availability of simulated cassava-vegetable diets. Plant Food for Human Nutrition 53: 367- 380. https://doi.org/10.1023/A:1008081217786

[80] Ajai A. I., Paiko Y. B., Jacob J. O., Ndamitso MM., Dauda J. (2016). Analysis of Cyanide and Essential Mineral Contents in Raw and Processed Cassava from Minna, Nigeria. American Chemical Science Journal 11(2): 1–6. https://doi.org/10.9734/ACSJ/2016/22758

[81] Ahenkora, K., Kyei, M. A., Marfo, E. K, Banful, B. (1996). Nutritional composition of False Horn Apantu pa plantain during ripening and processing. AfricanCrop Science Journal, 4(2): 243-247.

[82] Carvalho, EP., Canhos, VP., Ribeiro, VE., Carvalho, HP. (1996). Polvilho azedo: physical-chemical and microbiological aspects. Pesquisa Agropecuária Brasileira, 31, 129-137.

[83] Garcia, MC., Elias, TM., de Oliveira, RK., Soares JMS., Márcio, C. (2019). Microbiological and physicochemical profiles of the sour cassava starch and bagasse obtained from cassava agroindustry. Food Sci. Technol, Campinas, 39(4): 803-809. https://doi.org/10.1590/fst.32117

[84] Assanvo, JB., Agbo, GN., Behi, YEN., Coulin, P., Farah, Z. (2006). Microflora of traditional starter made from cassava for "attieke´" production in Dabou (Cote d'Ivoire). Food Control 17, 37-41. https://doi.org/10.1016/j.foodcont.2004.08.006

[85] Brasil, Ministério da Saúde. (2001, Jan 02). Resolução RDC n. 12, 02 de janeiro de 2001. Regulamento Técnico sobre Padrões Microbiológicos para Alimentos. Diário Oficial [da] Republica Federativa do Brasil.