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Production, Microbiological and Organoleptic Properties of Stored Cocoyam-based Products

David-Chukwu Nkiruka Phil[1], Onwuka Gregory Ikechukwu[2], Aji Rosemary Uloma[1], Odom Theophilus Chikodi[3], Chukwu Michael Nwankwo[3, *]

[1]Department of Hospitality Management and Tourism, Abia State Polytechnic, Aba, Nigeria

[2]Department of Food Science and Technology, Michael Okpara University of Agriculture, Umudike, Nigeria

[3]Department of Food Technology, Abia State Polytechnic, Aba, Nigeria

Email address:

mchukwu61@gmail.com (C. M. Nwankwo)

[*]Corresponding author

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Abstract: The production, microbiological and organoleptic properties of stored cocoyam-based products were carried out. A-5 kg corms were sorted, washed and boiled for 3 hours and was cooled, peeled and cut into small sizes of average of 2.0 cm by 1.5 cm dimension with a sharp kitchen knife; dried under the sun for 5 days. The dried corms (*achicha*) were pulverized with a locally fabricated machine and stored in plastic containers for 0, 1, 2, 3 month (s) intervals. A-300 g of cocoyam leaves were plucked, sorted, washed, and sun-dried for 3 days. The *mpoto* were pulverized with a locally fabricated machine and stored in plastic containers for 0, 1, 2, 3 months. After 3 months' storage, the total viable counts (TVC) and total fungi counts (TFC) of *achicha* were as follows: *edeofe* (2.8×10^4 *cfu/g*), *cocoindia* (3.4×10^4 *cfu/g*) and *anampu* (2.4×10^4 *cfu/g*); and *edeofe* (1.4×10^4 *cfu/g*), *cocoindia* (1.7×10^4 *cfu/g*) and *anampu* (0.8×10^4 *cfu/g*) respectively. The TVC and TFC of *mpoto* stored for 3 months were as follows: *edeofe* (2.7×10^4 *cfu/g*), *cocoindia* (2.1×10^4 *cfu/g*) and *anampu* (1.4×10^4 *cfu/g*); and *edeofe* (1.0×10^4 *cfu/g*), *cocoindia* (0.5×10^4 *cfu/g*) and *anampu* (0.5×10^4 *cfu/g*) respectively. The bacteria isolated and identified were *Bacillus* spp in *edeofe* and *cocoindia* of *achicha* and *mpoto*; *Staphylococcus* spp in *anampu* of *achicha* and *cocoindia* of *mpoto* and *Escherichia coli* in *anampu* of *achicha* and *edeofe* of *mpoto*. *Penicillum*, *Rhizopus* and *Aspergillus* spp were also identified in *achicha* and *mpoto* of all the varieties. The organoleptic properties of *achicha* and *mpoto* scored approximately 8.00 (like very much) which showed that the products were generally accepted due to low microbial loads and high preference on the desired attributes of *achicha* and *mpoto*. It is recommendable to use the tubers and the leaves in food preparations for human consumption.

Keywords: *Achicha*, *Mpoto*, Corm, Cormel, *Edeofe*, *Cocoindia*, *Anampu*, Storage, Counts

1. Introduction

Cocoyam (*Xanthosoma sagittifolium* and *Colocasia esculenta*) is an edible root crop grown in the tropics of which Nigeria is a major producer. It belongs to the *Araceae* family [1]. Cocoyam contributes significant portion of the carbohydrate content of the diet in many regions in developing countries and provide edible starchy storage corms or comels [2]. Cocoyam has nutritional advantages over other root and tuber crops [3]. *Colocasia esculenta* originated from humid tropical rainforest regions of south-east Asia including India. Various researchers conclude that it is not possible to determine a single place of origin for cocoyam [4]. Evidence from the highlands of Papua New Guinea, indicates that Taro processing was active by at least 10,000 years, while *Alocasia* and *Colocasia* starch residues have been found on stone implements from Buka, Solomon Islands that date back some 2,800 years ago [5]. The species

are discovered in the entire Pacific islands and worldwide. The bulk of world production of taro is in Africa followed by Asia. The major producers in Asia are China, Japan, Philippines and Thailand. In Africa, Nigeria, Ivory Coast, Ghana, Zaire (Congo) and Cameroon are the dominant producers [6].

Ammar *et al*. [7] noted that edible aroid flours could be advantageous in the preparation of myriad products in the food development industry since it could be used in dehydrated soup formulation, baking goods, formulation of baby food, snacks and breakfast products. The flour from cocoyam has been used in baking of products as it has been reported that cocoyam has fine starch granule, which improves binding and reduces breakage of snack products [8]. Recent studies show that cocoyam starch can be incorporated in the development of weaning food which is easily digestible and accessible to low income earners in developing countries [9, 10]. Recent works [11-13] have studied the moisture sorption isotherm of cocoyam flour, which according to Idlimam *et al*. [14] are important to improve the conditions of several processes such as dehydration, packaging or storage [15].

Processing taro corm affects its proximate, mineral, phytochemical and anti-nutrient contents. When taro corms processed into powder and further decrease will occur when processed into taro noodles and cookies [16, 17]. Therefore, the combination of cooking time temperature program is necessary to preserve the nutrients and deactivates the anti-nutritional factors. On the other hand, cooking increases antioxidant activity, crude fat, crude protein and crude fibre contents. Cooking substantially may be used in the management of non-communicable illnesses such as obesity, heart disease, blood pressure, diabetes, cancer and gastrointestinal disorders because of the high fibre content [16].

The main problem of taro is that the corms are usually prone to physical damage during harvesting and this leads to high post-harvest losses [18]. To overcome these losses, the corms and comels may be processed into flour. Several tuber products are harvested and preserved as flour after appropriate drying [17]. Some recent studies establish as simple process to produce flour from *Colocasia esculenta* roots. In this process, roots are cooked in its skin, peeled, sun dried and pulverized through 500µm sieves [19]. Alam and Hasinain [20] noted that this method affects functional and physicochemical properties of flour significantly due to starch granule disruption and such disrupted and pre-gelatinized flour can absorb water. Therefore, it can create binder properties which results in uniform matrix instantly when added to water. According to Alam and Hasinain [20], the Solubility of modified starch from *Colocasia esculenta* was studied and found that heat moisture treated starch is more soluble than raw starch. In addition, it was reported that pre-gelatinized product has higher overall acceptance [21]. Leaves are boiled and consumed as salad with spicy sauce, and petioles are cooked with coconut milk, meat and prawns [22]. When more common starches and green vegetables are in short supply, taro in the Philippines is used mainly. The corms are boiled, chipped and fried or made into confections. In Hawaii and parts of Polynesia, the corms are cooked and pounded into a paste which is allowed to ferment to produce 'poi'. A steamed pudding is produced from grated taro and coconut. Fiber gotten from the leaf stalk is used for planting. In Asia and Africa, this species is also used in traditional medicine to treat arterial hypertension, liver problems, ulcers, snake-bites, and rheumatism [23].

Post-harvest rot or spoilage of cocoyam tubers is attributed to physical, physiological and pathological factors. Chukwu *et al*. [24] stated that lack of suitable storage method reduces the availability of cocoyam for the entire year. This could limit the versatility of uses for which cocoyam is suitable. Conventional storage methods such as traditional cocoyam barn-heaping the cocoyam under shade and storage of cocoyam in pits have been tried and found to be ineffective due to high level of losses. According to Anaele and Nwawusi [25], losses as high as 40-60% are attributed to pathogens like *Botryodiplodia theobromae, Phythophthora infestans, Sclerotium rolfssi and Pythium myriotyium, Fusarium oxysporum* and *Fusarium solani.* The losses depict a cost to all the stakeholders in cocoyam cultivation, processing and marketing. This may be translated to a decline in their income and a threat to reliance on cocoyam as a food security crop in the current economic recession. There were efforts to decrease loss of cocoyam in storage at the NRCRI, Umudike, which led to the practice of burying cocoyam in the swamp [26]. This can be workable but with many disadvantages. The stored cocoyam usually sprouted and started germinating within four (4) weeks of storage. High physiological losses are brought about by sprouting. Nwufo and Atu [27] reported in a review of post-harvest losses of cocoyam that 50% loss after two months and about 95% after five months as a result of sprouting. Most farmers practice in-situ storage and harvest small portions to meet consumption or market demands. Also, this system ties up the land and limits its use for other purposes [28].

The cocoyam (*Colocasia esculenta*) is highly perishable root and leaves, crop as high as 40-60% postharvest losses have been found [25]. The high perishability of the harvested and stored cocoyam roots and leaves is a major barrier to the wider utilization of the crop and there is need to diversify the uses to enhance demand and increase the rate of turn over or sale of the product. Lack of adequate cocoyam processing technology inhibits production and processing. Over the years due to the high perishable nature of cocoyam local farmers had adopted sun-drying as a means of preserving the cocoyam. It becomes necessary to evaluate the effect of these processes and storage methods on the overall quality of the cocoyam products.

The main objective of this research is to produce *achicha* (dried cocoyam corms/cormels) and *mpoto* (dried cocoyam leaves). This can be achieved by determining the effect of storage periods (0-3 months intervals) on the microbiological

and organoleptic properties of *achicha* and *mpoto*. Processing of cocoyam corms/cormels and leaves into more shelf-stable dry products such as *achicha* and *mpoto* will reduce post-harvest losses of cocoyam, provide a market for small scale farmers, and diversify the uses of cocoyam. Evaluation of the quality and shelf stability of the *achicha* and *mpoto* would give confidence to the producers and consumers of these products.

2. Materials and Methods

2.1. Collection of Materials

Fresh cocoyam corms/cormels and leaves [*edeofe* (NCE 002), *cocoindia* (NCE 001) and ukpong/*anampu* (NCE 004)] were obtained from National Root Crop Research Institute, Umudike, Abia State, Nigeria. The fresh samples were identified by the Agronomist, Cocoyam Unit, National Research Institute Umudike, Abia State. The cocoyam corms/cormels and cocoyam leaves are shown in Figures 3, 4 and 5.

2.2. Processing of Corms/Cormels and Leaves into Achicha and Mpoto

2.2.1. Processing of Corms/Cormels into Achicha (Dried Cocoyam)

The cocoyam corms/cormels weighing 5 kg for each of the samples was sorted, washed and boiled for 3 hours. It was cooled, peeled and cut into small sizes of average of 2.0 cm by 1.5 cm dimension with a sharp kitchen knife. They were spread on a mat and dried under the sun for 5 days between 9 am - 6 pm. The dried cocoyam corms/cormels (*achicha*) were pulverized before storage with a locally fabricated machine and stored in various plastic containers for a period of three months and analyzed at 0, 1, 2- and 3-months intervals. The pictures of the cocoyam plant, cocoyam corms/cormels and cocoyam leaves and the processed *achicha* are shown in Figures 3, 4, and 5 respectively. Also, the flow diagrams of the production of *achicha* from cocoyam corms/ cormels is shown in Figure 1.

2.2.2. Processing of Cocoyam Leaves into Mpoto (Dried Cocoyam Leaves)

A sample of 300 g of cocoyam leaves were plucked, sorted, washed, spread on a mat and sun-dried for 3 days between 9 am – 6 pm. The steps taken in the preparation of the *achicha* and *mpoto* samples are shown in the flow chart in Figures 1 and 2 respectively. The dried cocoyam leaves (*mpoto*) were pulverized before storage with a locally fabricated machine and stored in various plastic containers for a period of 3months and analyzed at zero, one, two and three months. The picture of the dried cocoyam leaves is shown in Figure 6. Also, the flow chart of the cocoyam leaves is shown in Figure 2.

2.3. Microbiological Analysis

2.3.1. Culturing, Isolation and Characterization of Microorganism from the Samples

One gram (1 g) of the flour sample was serially diluted as follows: 10-fold serial dilution was carried out by filling ten sterile test tubes with 9 mls of sterile distilled water. One gram (1g) from each sample was added to the first test tube labeled 10^{-1} and 1 ml was transferred to the second test tube labeled 10^{-2}. The procedure continued to the tenth test tube. The pour plate method [29] was used. Sterile petri dishes were set up for required dilution. 1 ml dilution of 10^{-3} test tube was pipetted into the appropriately labeled plate. Nutrient agar was poured into the plate for bacterial isolation while potato dextrose agar was poured into the other groups for fungi isolation. These plates were duplicated for each group. The contents in the petri dishes were mixed by slightly moving the dishes in a clock-wise and anti-clock-wise direction. They were allowed to set and incubated at 37 ^{o}C for 18 hours (bacteria) while the plates for fungi isolation were incubated at 26 ^{o}C for 3 days. The plates were observed daily for colony growth (bacteria) while mycelia were observed daily for fungi. Similarly, this procedure was used for culturing of samples for microbial load [30].

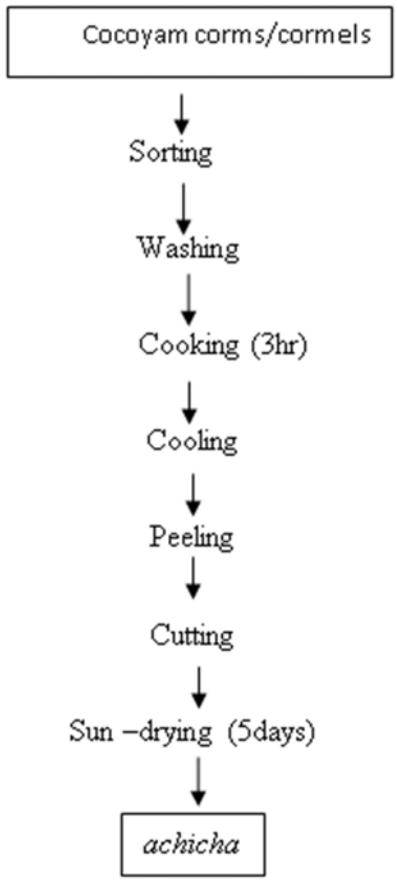

Figure 1. *The Flow diagram for the production of achicha.*

2.3.2. Purification of Isolate

Discrete colonies from the crowded primary plates were sub -cultured into newly prepared nutrient agar (bacteria) and potato dextrose agar for fungi. The bacteria plates were incubated at 37°C for 18 hours whereas, the fungi plates were incubated at 26°C for 3 days hence making pure

culture of the test organisms from the mixed cultured plates. The newly purified isolates were further picked and inoculated into freshly prepared nutrient agar and potato dextrose agar slants and stored in refrigerator at 4°C for future use [31].

2.3.3. Characterization of Isolates (Bacteria)

The following were used for bacteria identification as expressed by microscopic examination which is the physical morphology of the organisms-colour, texture, edge, odour and so on. Microscopic examination through gram stain method was done. Biochemical tests such as coagulase, oxidase, indole, urease, methyl red, sugar fermentation citrate was done as well for the characterization of the bacteria isolate [32].

Figure 2. *The Flow chart of the production of mpoto.*

2.3.4. Characterization of Isolates (Fungi)

A mycology atlas was used for identification through a wet mount method. A portion of the mycelium from each of the culture was dropped into a cotton blue in lacto-phenol on a clean glass slide. A cover slip was used to cover and examine under the microscope (X 40) [32].

2.3.5. Calculation of Microbial Load (cfu/g)

After 18 hours, the plates were observed for colony growth for bacteria while observation of fungi growth was `after 3 days. A Gallenkamp colony counter (model TT 201, USA) which was containing the colonies that appeared on the plates. The colours from the counting meter were recorded [33]. The plate count per g of the sample was calculated as the number of colonies on that plate x dilution factor = plate count per count per ml of the sample [29].

2.4. Preparation of Achicha Meal

Achicha was turned into granules by pounding with mortar and pestle. It was soaked in water for 30 minutes. Afterwards, it was squeezed out of water, wrapped with banana leaves and cooked for 30 minutes. Chopped onions were put into a pot containing palm oil. Then, *akpaka*, pepper and *fiofio* were added. Salt was also added to taste. The cooked *achicha* meal is shown in Figure 6.

Figure 3. *Colocasia esculenta Plant.*

Figure 4. *Colocasia esculenta leaves.*

Figure 5. *Colocasia esculenta corms/cormels.*

Figure 6. *Achicha meal.*

Figure 7. *Traditional Soup (Mpoto soup).*

2.4.1. Recipe for Achicha

Achicha (dried cocoyam chips): 600g
Fio-fio (pigeon peas): 264g
Akpaka (oil bean seed): 80g
Palm oil: 250ml
Onions: 100g
Fresh pepper: 15g
Salt: 13.95g

2.4.2. Procedure

Achicha was crushed into granules using mortar and pestle. It was washed and water decanted for three times. The *achicha* soaked in water for 30 minutes and squeezed out of water. It was wrapped with banana leaves and steamed for 30minutes. Onions was chopped and fresh pepper blended. Palm oil was heated up in another clean dry pot. Chopped onions was added to the hot oil and fried for 2 minutes. *Akpaka* and pepper were added and fried for another 2 minutes. *Fio-fio* was added. When the contents of the pot were heated up, the steamed *achicha* was added, stirred well and salt added.

2.5. Preparation of Traditional Soup (Mpoto Soup)

The dried *mpoto* leaves were further heated up in the oven for 5mins, crushed, washed and used to prepare soup. Meat and stockfish were washed, seasoned with chopped onions, stock cubes and salt. *Mangala* was washed the in hot water, bones were removed and added to pot containing meat and stockfish. Enough water was added to the soup and allowed boil. Palm oil, pepper, crayfish and groundnut paste were added. Then *mpoto* leaves were added. The picture of *mpoto* soup is shown in Figure 7.

2.5.1. Recipe for Traditional Soup (Mpoto Soup)

Meat (assorted): 1200g
Stockfish: 400g
Mangala (dried fish): 300g
Groundnut paste: 400g
Mpoto leaves (crushed dried cocoyam leaves): 30g
Crayfish (ground): 100g
Onions: 100g
Dry pepper: 10g
Salt: 13g
Water: 1085ml
Palm oil: 200ml
Stock cubes (Knorr): 2 cubes

2.5.2. Procedure

Assorted meat and stock fish were washed separately. The meat and stock-fish were seasoned with chopped onions, stock cubes and salt and cooked for 20 minutes. Then, *mangala* was cleaned in hot water; bones were removed and add the pot of meat and stock-fish. Palm oil, pepper, crayfish, and groundnut paste were added and stirred well. Pot was covered and left to boil for 10 minutes. *Mpoto* leaves were added; allowed to simmer for 5 minutes.

2.6. Sensory Evaluation

The Hedonic test was used to measure the degree of liking for the samples of *achicha* meal and *mpoto* soups. The 9-point Hedonic scale was used for preference testing. The midpoint of the hedonic scale used in this study is "neither like nor dislike" which is rated 5 and category scales ranging from "like extremely" (9), "like very much" (8), "like moderately" (7), "like slightly" (6) "neither like nor dislike" (5), "dislike slightly" (4), "dislike moderately" (3), "dislike very much" (2) and "dislike extremely" (1), with varying numbers of categories were used [34, 35]. Thirty-one semi–trained panelists were asked to carry out the sensory quality of *achicha* meals and *mpoto* soups prepared from three varieties of *Colocasia*. The samples were presented and evaluated on the basis of the following sensory attributes; aroma, appearance, texture, taste and overall acceptability.

2.7. Statistical Analysis

All analysis was carried out in triplicates. The experiment was laid out in a completely randomized design (CRD). The data obtained were analyzed statistically using analysis of variance (ANOVA) at 5% level of significance while Duncan test was used to separate the factor means [36].

3. Results and Discussion

3.1. Microbiological Properties of Achicha and Mpoto During Three Months Storage

3.1.1. Total Viable Count (TVC) (Cfu/g) of Achicha During Three Months Storage

The results in Table 1 shows the comparison of mean total viable count of *achicha* processed from three different *Colocasia* varieties (*edeofe*, *cocoindia*, and *anampu*) stored from zero to three months. The total viable count indicated that the *achicha* samples varied significantly ($p<0.05$) from 1.60×10^4 to 3.40×10^4 with *cocoindia* at three months having the highest viable count (3.40×10^4) and *anampu* at zero month having the least viable count (1.60×10^4). The results obtained are consistent with AOAC [37] which should not exceed 300 colonies and this indicates that all the samples analyzed were safe for consumption and their shelf life could be extended if packaged well and stored.

3.1.2. Total Viable Count (TVC) (cfu/g) of Mpoto During Three Months Storage

The results in Table 2 shows the comparison of mean total

viable count of *mpoto* processed from three different *Colocasia* varieties (*edeofe*, *cocoindia*, and *anampu*) stored for three months. The total viable count indicated that the *mpoto* samples varied significantly ($p<0.05$) from 1.20 x 10^4 to 2.70 x 10^4 with *edeofe* at three months having the highest viable count (2.70 x 10^4) and *anampu* at zero month having the least viable count (1.20 x 10^4). There was no significant ($p> 0.05$) difference among the samples. The results obtained are consistent with AOAC [37] which should not exceed 300 colonies and this indicates that all the samples analyzed were safe for consumption and their shelf life could be extended if packaged well and stored.

Table 1. *Total Viable Count (TVC) (cfu/g) of Achicha during Three Months Storage.*

Sample	TVC (M)			
	0	1	2	3
Edeofe	2.40 x 10^{4de}±0.70	2.50 x 10^{4de}±0.30	2.70 x 10^{4cd}±0.30	2.80 x10^{4ab}±0.30
Cocoindia	3.00 x 10^{4ab}±0.20	3.20 x 10^{4ab}±0.70	3.30x10^{4ab}±0.20	3.40 x 10^{4a}±0.30
Anampu	1.60 x 10^{4f}±0.30	1.60 x 10^{4f}±0.30	2.00 x 10^{4ef}±0.30	2.40 x 10^{4de}±0.70

Values are means of three independent determinations±SD. Means in the same row with the same superscript are not significantly P> 0.05 different.

Table 2. *Total Viable Count (TVC) (cfu/g) of Mpoto during Three Months Storage.*

Samples	TVC (M)			
	0	1	2	3 `
Edeofe	1.9 x 10^{4cd}±0.3	2.1 x 10^{4bc}±0.14	2.4 x 10^{4ab}±0.00	2.7 x 10^{4a}±0.00
Cocoindia	1.4 x 10^{4e}±0.3	1.7 x 10^{4cd}±0.14	1.8 x 10^{4cd}±0.00	2.1 x 10^{4bc}±0.00
Anampu	1.2 x 10^{4g}±0.3	1.3 x 10^{4fg}±0.14	1.5 x 10^{4de}±0.00	1.7 x 10^{4cd}±0.00

Values are means of three independent determinations±SD. Means in the same row with the same superscript are not significantly P> 0.05 different.

3.1.3. Total Fungal Count (TFC) (cfu/g) of Achicha During Three Months Storage

The results in Table 3 shows the comparison of mean total fungal count of *achicha* processed from three different *Colocasia* varieties (*edeofe*, *cocoindia*, and *anampu*) stored from zero to three months. The total fungal count indicated that the *achicha* samples varied significantly ($p<0.05$) from 0.30 x 10^4 to 1.70 x 10^4 with *Cocoindia* at three months having the highest viable count (1.70 x 10^4) and *anampu* at zero month having the least viable count (0.30 x 10^4). The results obtained are consistent with AOAC [37] which should not exceed 300 colonies and this indicates that all the samples analyzed were safe for consumption and their shelf life could be extended if packaged well and stored. Fungal contamination can lead to discolouration of chips give rise to mouldy taste and produce off odours.

3.1.4. Total Fungal Count (TFC) (cfu/g) of Mpoto During Three Months Storage

The results in Table 4 shows the comparison of mean total fungal count of *mpoto* processed from three different *Colocasia* varieties (*edeofe*, *cocoindia*, and *anampu*) stored for three months. The total fungal count indicated that the *mpoto* samples varied significantly ($p<0.05$) from 0.00 x 10^4 to 1.00 x 10^4 with *edeofe* at three months having the highest viable count (1.00 x 10^4) and *cocoindia* at zero month having the least fungal count (0.02 x 10^4), while *anampu* at zero month did not show any fungal growth at all. There was no significant difference ($p> 0.05$) in the values obtained. The results obtained are consistent with AOAC [37] which should not exceed 300 colonies and this indicates that all the samples analyzed were safe for consumption and their shelf life could be extended if packaged well and stored.

3.1.5. Biochemical and Morphological Characteristics of Bacterial Isolates

The result of the biochemical test conducted on the bacteria isolates during 3 months' storage period is shown in Table 5. The most predominant organisms identified from the biochemical test in the products of three varieties were *Bacillus* species followed by *Staphylococcus* spp and *E. coli*. However, from the above result, it could be detected that *Bacillus* spp were not the only microorganism that involved during the three month (s) storage of *achicha* and *mpoto*. There is evidence that a combination of *Bacillus*, *Staphylococcus and E. coli* [25]. *Bacillus* was found in the *achicha* and *mpoto* samples of *edeofe* and *cocoindia* varieties while *Staphylococcus* was identified in *achicha* samples of *anampu* variety and *mpoto* samples of *cocoindia* variety; whereas *E. coli* was identified as gram-negative rod in the samples of *achicha* and *mpoto* of *edeofe* variety.

Table 3. *Total Fungal Count (TFC) (cfu/g) of Achicha during Three Months Storage.*

Samples	TFC (M)			
	0	1	2	3
Edeofe	0.60 x 10^{4cd}±0.30	0.80 x 10^{4bcd}±0.30	1.10 x 10^{4bc}±0.28	1.40 x 10^{4ab}±0.30
Cocoindia	0.80 x 10^{4bcd}±0.14	1.00 x 10^{4b}±0.14	1.40 x 10^{4ab}±0.30	1.70 x 10^{4a}±0.30
Anampu	0.30 x 10^{4e}±0.30	0.30 x $10^{4e\pm}$0.28	0.50 x 10^{4cd}±0.30	0.80 x 10^{4bcd}±0.30

Values are means of three independent determinations±SD. Means in the same row with the same superscript are not significantly P> 0.05 different.

Table 4. *Total Fungal Count (TFC) of Mpoto stored for Three Months (cfu/g).*

Samples	TFC			
	0 month	**1 month**	**2 months**	**3 months**
Edeofe	$0.5x\ 10^{4ab}$±0.00	$0.5\ x\ 10^{4ab}$±0.07	$0.8\ x\ 10^{4a}$±0.14	$1.0\ x\ 10^{4a}$±0.40
Cocoindia	$0.2\ x\ 10^{4b}$±0.02	$0.3\ x\ 10^{4b}$±0.07	$0.3\ x\ 10^{4b}$±0.30	$0.5\ x\ 10^{4ab}$±0.14
Anampu	-	$0.1\ x\ 10^{4b}$±0.00	$0.3\ x\ 10^{4b}$±0.00	$0.5\ x\ 10^{4ab}$±0.00

Values are means of three independent determinations±SD. Means in the same row with the same superscript are not significantly P> 0.05 different.

Table 5. *Biochemical and Morphological Characteristics of Bacterial Isolates.*

Sample	Micro Morphology	Gram	Catalase	Oxidase	Coagulase	Indole	M. R	V. P
Edeofe (*achicha*)	Rods	+	+	-	-	-	-	+
Coco india (*achicha*)	Rods	+	+	-	-	-	-	+
Anampu (*achicha*)	Cocci	+	+	-	+	-	_	_
Anampu (*achicha*)	Rods	-	+	-	-	+	+	+
Edeofe (*mpoto*)	Rods	-	+	-	-	-	-	+
Edeofe (*mpoto*)	Rods	+	+	-	-	-	-	+
Coco india (*mpoto*)	Cocci	+	+	-	-	-	-	-
Cocoinda (*mpoto*)	Rods	+	+	-	-	-	-	+

Table 5. *Continued.*

Sample	Citrate	Spores	Glucose	Sucrose	Lactose	Probable organisms
Edeofe (*achicha*)	-	+	A/G	A	A	*Bacillus spp.*
Coco india (*achicha*)	-	+	A/G	A	A	*Bacillus spp.*
Anampu (*achicha*)	_	_	A	A	A	*Staphylococcus spp.*
Anampu (*achicha*)	-	-	A/G	A	A/G	*E. coli*
Edeofe (*mpoto*)	-	-	A/G	A	A/G	*E.coli*
Edeofe (*mpoto*)	-	+	A/G	A	A	*Baccilus spp.*
Coco india (*mpoto*)	-	-	A/G	A	A	*Staphylococcus spp.*
Cocoinda (*mpoto*)		+	A/g	A/-	A/-	*Bacillus spp.*

Key:
(-) =Negative
(+) = positive
M R= methyl rod
V. P = Voges Prauskuer
A/G = Acid and Gas Production
A = Acid production

3.1.6. Cultural and Morphological Characteristics of Fungi

The results in Table 6 showed the cultural and microscopic characteristics of fungi isolated during the storage of *achicha* and *mpoto* for 3 months. After three month (s) storage of *achicha* and *mpoto*, *Penicillum* spp, *Rhizopus* spp and *Aspergillus* were identified on the potato dextrose agar plate, which are the organisms known to break down of carbohydrates to sugar in cocoyam-based products mainly. However, *Penicillum* was identified in *achicha* samples of *edeofe* variety and *mpoto* samples of *cocoindia* and *anmpu* varieties whereas *Rhizopus* was also identified in *achicha* samples of *edeofe* and *mpoto* samples of *edeofe* and *anampu* varieties. *Aspergillus* was also identified in *achicha* samples of *edeofe*, *cocoindia* and *anampu* varieties and also in *mpoto* samples of *cocoindia* variety. Therefore, it is due to the carbohydrate content of the cocoyam. The presence of fungi during storage could be the contamination possibly from the processing environment [31].

Table 6. *Cultural and Morphological Characteristics of Fungi.*

Samples	Culture	Morphology	Probable fungi
Edeofe (*achicha*) *Cocoindia* (*mpoto*) *Anampu* (*mpoto*)	Bluish gray colonies folding in the centre	Thick walled, no septation, oval spores, occurs in chains and sometimes singly.	Penicillum spp.
Edeofe (*achicha*) *Edeofe* (*mpoto*) *Anampu* (*mpoto*)	Black colonies with long antenally branched hyphae with spores.	They possess non-septate mycelia, rhizoids and stolons, the sporangiu were also present.	Rhizopus spp.
Edeofe (*achicha*) *Cocoindia* (*achicha/mpoto*) *Anampu* (*achicha*)	Gray colonies on culture plates.	Possess stalk-like conidio spores with large versciles covered with sterigmata.	Aspergillus spp.

Table 7. *Sensory Evaluation of Achicha from Three Varieties of Colocasia esculenta.*

Samples	Aroma	Appearance	Texture	Taste	Overall Acceptability
Edeofe	7.53^{a}±0.87	7.50^{ab}±0.80	7.50^{ab}±0.13	7.25^{ab}±0.00	7.63^{ab}±0.00
Cocoindia	7.50^{a}±0.69	7.49^{a}±0.18	7.63^{a}±1.41	7.42^{a}±0.01	7.71^{a}±0.01
Anampu	7.52^{a}±0.57	7.40^{a}±0.39	7.04^{b}±0.50	7.13^{ab}±0.79	7.41^{c}±0.75

Values are means±SD of replicate determinations (N =31). Means in the same row with the same superscript are not significantly P> 0.05 different.

Table 8. *Sensory Evaluation of Mpoto Soup from Three Varieties of Colocasia esculenta.*

Samples	Aroma	Appearance	Texture	Taste	Overall Acceptability
Edeofe	8.25^{a}±0.48	7.50^{b}±0.72	7.63^{b}±0.76	8.13^{c}±0.40	8.13^{a}±0.45
Cocoindia	8.13^{a}±0.40	7.67^{ab}±0.51	8.00^{a}±0.52	8.33^{b}±0.34	8.25^{a}±0.51
Anampu	7.80^{b}±0.54	7.92^{a}±0.48	7.96^{a}±0.54	8.56^{a}±0.37	8.17^{a}±0.52

Values are means±SD of replicate determinations (N =31). Means in the same row with the same superscript are not significantly P> 0.05 different.

3.2. Organoleptic Properties of Achicha and Mpoto During the Three Months Storage

The result in Table 7 and 8 shows the comparison of mean score of organoleptic properties of *achicha* and *mpoto* processed from three different *Colocasia* varieties (*edeofe*, *cocoindia*, and *anampu*) stored for 0, 1, 2, 3 month (s).

3.2.1. Aroma

Aroma is an important parameter of food [38]. "Good aroma from food excites the taste buds, making the system ready to accept the product. 'Poor' aroma may cause outright rejection of food before they are tasted. There was no significant difference ($p>0.05$) among the three *achicha* samples for aroma. The highest score for aroma was observed in *edeofe* (7.53) which showed it was above "like moderately", while the lowest aroma scored was found in *cocoindia* (7.50) which above "like moderately" by implication, it was acceptable (Table 7). The mean aroma score of *mpoto* samples varied significantly ($p<0.05$) from 7.80 to 8.25. This means that the samples rated above "like moderately" to a little above "like very much". Sample *edeofe* (8.25) rated highest in aroma, which meant that *edeofe* was liked very much; while *anampu* had the lowest score (7.80). The *mpoto* samples were not significantly ($p> 0.05$) different. *Edeofe* and *Cocoindia* were significantly ($p>0.05$) similar in aroma (Table 8).

3.2.2. Appearance

There was no significant difference ($p>0.05$) among the three *achicha* samples. The highest appearance score was awarded to *edeofe* (7.50) followed by *cocoindia* (7.49) and *anampu* had the least score of 7.40 (Table 7). All the three samples scored above "like moderately" and were acceptable. Appearance of food is the first identity and often a prediction of the degree of satisfaction or pleasure to be derived from eating a given food [39]. Appearance is an important sensory attribute, which can enhance acceptability. The local population thinks that pale coloured food is less attractive. Besides, it is assumed that bright foods impart nutrients. The mean appearance score of *mpoto* samples ranged from 7.50 to 7.92 (Table 8). All the three samples were above "like moderately". Sample *anampu* (7.92) rated highest among the samples, followed by sample *cocoindia* (7.67) and the least was *edeofe* (7.50). All the samples were significantly ($p>0.05$) the same [39].

3.2.3. Texture

The mean texture scores of *achicha* samples ranged from 7.04 to 7.63. The entire samples *edeofe* (7.50), *cocoindia* (7.63) and *anampu* (7.04) were not significantly ($p>0.05$) different. The highest score for texture occurred in sample *cocoindia* (7.63), while sample *anampu* (7.04) rated lowest in texture (Table 7). This signified that all the samples were acceptable and scored above "like moderately" Texture usually referred to as mouth-feel. Food texture sometime embraces appearance [40]. The mean texture score of the *mpoto* samples varied from 7.63 (above like moderately) to 8.00 (like very much). Sample *cocoindia* (8.00) rated highest which implied that *cocoindia* was liked very much, while sample *edeofe* (7.63) rated lowest, which showed that *edeofe* was liked moderately. There was a significant difference ($p>0.05$) between *edeofe* and other samples [40].

3.2.4. Taste

The mean taste scores of the *achicha* samples varied from 7.13 to 7.42 (Table 7). Sample *coocindia* rated highest (7.42), followed by *edeofe* (7.25) and the least score was *anampu* (7.13). The three samples did differ not significantly ($p>0.05$). The *achicha* samples were all acceptable and above "like moderately". The sense of taste is a *chemical* sense and responds to the actions of the chemical components of foods on the receptor sites of the taste buds, located mainly on the tongue [39]. The *mpoto* soup showed statistically ($p<0.05$) different sensory ratings for samples in taste. Although sample *anampu* (8.56) rated highest followed by *cocoindia* (8.33) and the least scored sample in taste was (8.13). All the samples rated above "like very much". There was a significant difference ($p>0.05$) among samples (Table 8).

3.2.5. Overall Acceptability

Overall acceptability was determined on the basis of quality scores obtained from the evaluation of taste, texture, aroma and appearance. The Overall acceptability scores of the *achicha* samples varied significantly ($p<0.05$) from 7.41 to 7.71 (Table 7). It was evident that sample *cocoindia* (7.71) was more acceptable and *anampu* (7.41) was least acceptable and varied significantly ($p<0.05$) from the other samples. The

entire samples rated above "like moderately". The three samples of *mpoto* showed statistically ($p>0.05$) similar sensory ratings. The highest scored sample in the overall acceptability was *cocoindia* (8.25) which meant that *cocoindia* was mostly accepted by the panelists, while samples *anampu* (8.17) and *edeofe* (8.13). The three samples rated above "like very much". In general, the overall acceptability of the dried cocoyam leaves in soup depended on the individual data of different sensory attributes such as appearance, aroma, texture and taste. All the samples were within the range of "like very much" (Table 8).

4. Conclusion and Recommendations

4.1. Conclusion

This study showed the effect of variety and storage time on the microbiological and organoleptic properties of *Colocasia* based products (*achicha* and *mpoto*). The low microbial loads of these cocoyam-based products, their shelf-life could be extended if stored well and they are safe for consumption. The study also indicated that the organoleptic qualities of the products were highly acceptable when incorporated in food preparations.

4.2. Recommendations

Efforts should be geared towards determining and perfecting proper food processing techniques to encourage the full inclusion of *mpoto* leaves in the list of vegetables in recipes for traditional cuisines. Both *achicha* meal and *mpoto* soup can contribute significantly to the nutrient requirements of humans and could be recommended as cheap sources of nutrients.

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