

Production, Proximate Compositions and Dry Matters of Stored *achicha* and *mpoto* - Cocoyam Based Products

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Abstract: The production, proximate compositions and dry matters of stored *Achicha* and *Mpoto* were conducted. Fresh cocoyam corms/cormels and leaves [*ede ofe* (NCE 002), *cocoindia* (NCE 001) and *ukpong/anampu* (NCE 004)] were obtained from National Root Crop Research Institute, Umudike, Abia State, Nigeria. A-5 kg cocoyam corms/cormels of the samples was 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. They were spread on a mat and dried under the sun for 5 days. The dried cocoyam corms/cormels (*achicha*) were pulverized before storage with a locally fabricated machine and stored in various plastic containers for 0, 1, 2, 3 months intervals. A sample of 300 g of cocoyam leaves were plucked, sorted, washed, spread on a mat and sun-dried for 3 days. The dried cocoyam leaves (*mpoto*) were pulverized before storage with a locally fabricated machine and stored in various plastic containers for 0, 1, 2, 3 months. The proximate compositions and dry matters of 3 different varieties of 4 samples of stored *Achicha* and *Mpoto* were determined. The results of stored *Achicha* showed that *Edeofe* had the least contents in moisture (12.33%) and *Anampu* had least contents in crude fibre (1.64%) and carbohydrate content (75.65%); *Edeofe* had the highest contents in ash (3.83%), crude protein (4.78%), crude fat (0.93%), and *Cocoindia* had the highest contents of dry matter (87.79%) after 3 months storage. The proximate compositions of stored *Mpoto* showed that *Edeofe* had the least moisture content (10.16%), *Anampu* had the highest contents in ash (14.92%), *Edeofe* had the highest contents in crude protein (15.19%), crude fat (0.89%), crude fibre (8.74%), dry matters (89.85%); and *Cocoindian* had highest carbohydrate content (51.08%) after 3 months storage. This showed that stored *Mpoto* samples were richer in ash, crude protein, crude fibre and dry matters than the stored *Achicha* samples which were richer in moisture, crude fat and carbohydrate contents. It is recommendable to use the tuber and the leaves in food preparations for human consumption.

Keywords: Corm, Cormel, Protein, Fat, Fibre, Ash, Carbohydrate, Moisture, *Edeofe*, *Cocoindia*

1. Introduction

Cocoyam is commonly referred to as *Ede* in Igbo land of Nigeria. Cocoyam's Taro and Tannia have remained the two varieties mainly grown in Nigeria [1]. The taro varied botanically known as *Colosasia esculenta* and commonly called Coco-India originated from Asia, while tannia (*Xanthosoma sagittifolium*) originated from America but were

both introduced and grown in West Africa [2]. These two species *Colocasia esculenta* (Taro) and *Xanthosoma sagittifolium* (Tannia) are the most widely accepted and cultivated varieties in Nigeria and other parts of the tropics and sub-tropic of Africa [3]. *Colocasia* is thought to have originated into Indo-Malayan region, perhaps in Eastern India

and Bangladesh, and spread eastward into South East Asia, Eastern Asia and the Pacific Island; Westward to Egypt and the Eastern Mediterranean, and then Southern and Westward from there into East Africa and West Africa, whence it spread to the Caribbean and Americans [4]. It is known by many local names and often referred to as Elephant-ears when grown as an ornamental plant [5].

Taro plant is a perennial herb with clusters of long heart or arrow head-shaped leaves that point earthward. It is cultivated in the tropics, and the leaves are classified as large to very large, 20 to 150 cm (7.6 to 5.9 in) long, with a sagittate shape [6], growing on erect stems which may be green, red, black, or variegated. The new leaves and stems push out of the innermost stalk, unrolling as they emerge, with the stem several feet high [7]. Taro corms contains considerable amount of starch (70 to 80 g/100g dry Taro). Lebot [8] did report taro corms to be rich in starch (61 to 88% DM) but little of protein (2.3 to 14.8 % DM) [9]. The corm contains mainly starch and water together with small quantities of protein, fat, ash, vitamins B and C. The carbohydrate content of taro cultivated in different locations varied. The starch extracted from taro corms appears as fine granules in the 0.5 to 5 microns range [10], and thus offers smooth textured starch gel [1]. Moreover, the fine starch granule was reported to improve the binding and reduced breakage of snack products [9, 11]. Meanwhile, taro leaves have been said to have a variable but generally high protein content usually in the 16 to 27% DM range [5] even though lower values (13 to 16 % DM) are also reported. Moreover, the leaves are a good source of thiamin, riboflavin, iron, phosphorus and zinc and a very good source of vitamin C, B₆, niacin, potassium, copper and magnesium [12]. Cocoyam is most commonly grown for its starchy edible roots [7] containing several vitamins and minerals. Cocoyam also has appreciable content of crude fibre which aids in digestion and makes the elimination of stool very easy, as well as playing major role in preventing cancer [3, 4].

The cocoyam (*Colocasia esculenta*) is highly perishable root and leaves, as high as 40-60% post-harvest losses have been found [13]. 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 [2]. 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 [6].

Cocoyam is an indigenous root crop that has not been utilized like other root crops such as cassava and yam. Despite the high nutritional value of cocoyam and soybean in relation to other root crops and legumes, lack of knowledge of their uses has limited their adoption, production and processing [13]. To bridge the gap, efforts are being made by research institutes, Non-Governmental Organizations (NGOs) and industries to promote the

production, processing and utilization of cocoyam in Nigeria [4]. As there is a growing interest in the production of flours from locally available grains that can be used as substitutes for wheat in baked goods, this study was undertaken to produce sausage rolls of acceptable quality from cocoyam, soybean and wheat flour blends. It is mostly used as thickener in soup and few indigenous recipes. Therefore, its conversion into flour could be used efficiently in baking technology. Nigeria faces one of the most serious nutritional problems in protein-energy malnutrition. Nigeria has not been able to produce wheat in commercial quantity due to climatic and soil conditions [2, 15].

The main objectives of this study are to produce *achicha* (dried cocoyam corms/cormels) and *mpoto* (dried cocoyam leaves) and to evaluate the effect of storage periods (0-3 months intervals) on the proximate and dry matter compositions of cocoyam-based products.

2. Materials and Methods

2.1. Collection of Materials

Fresh cocoyam corms/cormels and leaves [*ede ofe* (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 and 4.

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

The cocoyam corms/cormels weighing 5kg for each of the samples was sorted, washed and boiled for 3hrs. 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 9am- 6pm. 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, 5 and 6 respectively. Also, the flow diagrams of the production of *achicha* from cocoyam corms/ cormels is shown in Figure 1.

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

A sample of 300g of cocoyam leaves were plucked, sorted, washed, spread on a mat and sun-dried for 3 days between 9am-6pm. 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.

2.4. Proximate Analysis of Achicha and Mpoto Samples

Proximate analysis of *achicha* and *mpoto* (dried cocoyam corms/cormels and leaves) samples were evaluated for moisture, ash, crude protein, crude fibre, fat, and carbohydrate contents by the methods of AOAC [16] and Onwuka [17], and were determined in triplicates.

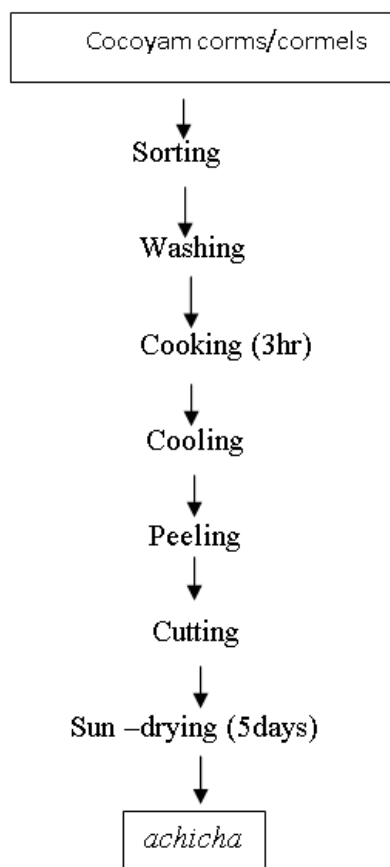


Figure 1. The Flow diagram for the production of achicha.

2.4.1. Determination of Moisture Content

The moisture content was determined by the gravimetric methods as described by Onwuka [17, 18]. A measured weight of each sample (5g) was put into a weighed moisture crucible. The weight of the crucible and the sample were taken. The crucible and its sample content were dried in the oven at 105°C for 3 hours at first. They were cooled in desiccators and reweighed. The weights were recorded while the samples were returned to the oven for further drying. The drying, cooling and weighing continued repeatedly until a constant weight was obtained. The weight of the moisture lost was determined by differences and expressed as a percentage. It was calculated as shown in Equation 1:

$$\% \text{ Moisture} = \frac{W_2 - W_3}{W_2 - W_1} \times 100 \quad (1)$$

Where:

W_1 = Initial Weight of empty crucible

W_2 = Weight of Crucible and sample before drying

W_3 = Final weight of crucible and sample after drying at a constant weight.

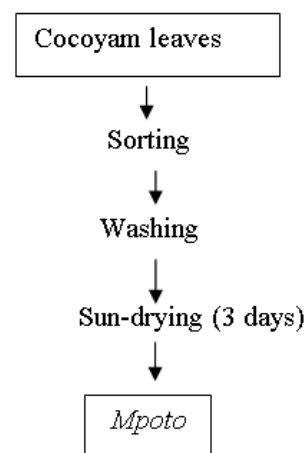


Figure 2. The Flow chart of the production of mpoto.

2.4.2. Determination of Total Ash Content

This was done using the furnace incineration gravimeter methods [16]. A measured weight (5 g) of each sample was put into a previously weighed porcelain crucible. The samples in crucible were put in a muffle furnace set at 500°C and allowed to burn for 3 hours (until the sample became grey ash). The sample in crucible was carefully removed from the furnace (taking care not to allow air blow the ash away) and cooled in a desiccator. It was reweighed; weight of the ash was obtained by difference and expressed as a percentage given by the Equation 2:

$$\% \text{ Ash (Dry basis)} = \frac{W_3 - W_1}{W_2 - W_1} \times 100 \quad (2)$$

Where

W_1 = Weight of empty crucible

W_2 = Weight of crucible + food before drying and/ or ashing

W_3 = Weight of crucible + ash

2.4.3. Determination of Crude Protein

The crude protein was determined by Kjeldahl method described by Onwuka [17, 18]. The total nitrogen was determined and multiplied with the factor 6.25 to obtain the protein. For each sample, 5 g was mixed with 10 ml of concentrated sulphuric acid, AR grade (Analytical Reagent Grade) in a Kjeldahl digestion flask. A tablet of selenium catalyst was added to it and the mixture digested (heated) under a fume cupboard until a clear solution was obtained in a separate flask. The acid and other reagent were digested but without sample to form the blank (control). All the digests were carefully transferred to 100 ml volumetric flask using distilled water and made up to a mark in the flask. A 100 ml portion of each digest was mixed with equal volume of 45% NaOH solution in Kjeldahl distilling unit. The mixtures were distilled and the distillate collected into 10 ml of 4% boric acid solution containing 3 drops of mixed indicator

(bromocresol green and methyl red). A total of 50 ml distillate was obtained and titrated against 0.02 M H₂SO₄ solution. Titration was done from the initial green colour to a deep red end point. The Nitrogen content was calculated as shown in Equation 3:

$$\% N_2 = \frac{100}{W} \times \frac{N \times 14}{100} \times \frac{V_f}{V_a} \times T \quad (3)$$

Where:

W = Weight of sample analyzed

N = Concentration of H₂SO₄ hydrant

V_f = Total volume of digest

V_a = Volume of digest distilled

T = Titre value of blank.

2.4.4. Determination of Crude Fibre

This was determined by Wende methods [17]. A 5 g of each sample was defatted (during fat analysis). The defatted sample was boiled under reflux for 30 mins with 200 ml of a solution containing 1.25g of H₂SO₄ per 100ml solution. After that the samples were washed with several portions of not boiling water using a two- folds muslin cloth to trap the particle, until the washings were no longer acidic. The washed samples were carefully transferred quantitatively back to the flask and 200ml of 1.25g of NaOH solution was added to it. Again, the samples were boiled for 30 min. and washed as before with hot water. They were then carefully transferred to a weighed porcelain crucible and dried in the oven at 105°C for 3 hours. After cooling in a desiccator, they were reweighed (W₂), then put in a muffle furnace and burnt at 550°C for 2 hours (until they became ash). Again, they were cooled in desiccators and reweighed. The crude fibre content was calculated gravimetrically as shown in Equation 4:

$$\% \text{ Crude Fibre} = \frac{W_2 - W_3}{W_1} \times 100 \quad (4)$$

Where;

W₁ = Weight of sample.

W₂ = Weight of crucible and sample before incineration.

W₃ = Weight of crucible and sample ash.

2.4.5. Determination of Fat Content

Fat content of the sample was determined by the continuous solvent extraction methods using a Soxhlet apparatus. The methods as described by AOAC [17]. A measured weight of 5g of each sample was wrapped in a porous paper (Whatman No. 1 filter paper). The wrapped samples were put in a Soxhlet reflux flask containing 200ml of petroleum ether. The upper end of the reflux flask was connected to a condenser by heating the solvent in the flask through electro-thermal heater, it vaporized and condensed into the reflux flask. Soon, the wrapped samples were completely immersed in the solvent and remained in contact with the solvent until the flask is filled up and siphoned over them carrying oil extract from the samples down to the boiling flask. The process was allowed on repeatedly for 4 hours before the defatted samples were removed and reserved for crude fibre analysis. The solvent was recovered and the extracting flask with its oil content was

dried in the oven at 60°C for 3 minutes (to remove any residual solvent). After cooling in a desiccator, the flask was reweighed. By difference, the weight of fat (oil) extraction was determined and expressed as a percentage of the sample weights as shown in Equation 5:

$$\% \text{ Fat} = \frac{\text{Weight of fat}}{\text{weight of sample}} \times 100 \quad (5)$$

2.4.6. Determination of Carbohydrate

The carbohydrate content was calculated by difference as the nitrogen free extractive (NFE): a method separately described by Onwuka [17] as shown in Equation 6:

$$\% \text{ NFE} = 100 - \% (a + b + c + d + e) \quad (6)$$

Where:

a = Protein, b = fat, c = fibre, d = ash, e = moisture.

2.5. Determination of Dry Matter

The moisture content was determined by the gravimetric methods as described by Onwuka [17, 18]. A measured weight of each sample (5g) was put into a weighed moisture crucible. The weight of the crucible and the sample were taken. The crucible and its sample content were dried in the oven at 105°C for 3 hours at first. They were cooled in desiccators and reweighed. The weights were recorded while the samples were returned to the oven for further drying. The drying, cooling and weighing continued repeatedly until a constant weight was obtained. The weight of the moisture lost was determined by differences and expressed as a percentage. It was calculated as shown in Equation 7:

$$\% \text{ Moisture} = \frac{W_2 - W_3}{W_2 - W_1} \times 100 \quad (7)$$

Where:

W₁ = Initial Weight of empty crucible

W₂ = Weight of Crucible and sample before drying

W₃ = Final weight of crucible and sample after drying at a constant weight.

% total solid (dry matter) = 100 - % moisture.

2.6. 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 Least Significant Difference was used to separate the factor means [19].

3. Results and Discussion

3.1. Proximate and Dry Matter Compositions of Achicha During Three Months Storage

Table 1 showed the comparison of mean Proximate Composition of *achicha* processed from three different *Colocasia* varieties (*edeofe*, *cocoindia*, and *anampu*) during three months storage.

Table 1. Proximate and Dry matter Compositions (%) of *Achicha* during Three Months Storage.

Proximate	Edeofe (M)			
	0	1	2	3
Moisture	10.27 ^e ±0.03	10.75 ^e ±0.03	10.84 ^d ±0.03	12.33 ^c ±0.03
Ash	4.31 ^a ±0.03	4.17 ^b ±0.03	3.94 ^d ±0.03	3.83 ^c ±0.03
Crude Protein	5.77 ^a ±0.03	5.44 ^b ±0.03	4.81 ^c ±0.03	4.78 ^f ±0.03
Crude Fat	1.05 ^a ±0.03	1.03 ^a ±0.03	0.95 ^{bc} ±0.03	0.93 ^{bc} ±0.03
Crude Fibre	2.21 ^a ±0.03	2.16 ^a ±0.03	2.15 ^a ±0.03	1.91 ^b ±0.03
CHO	76.39 ^e ±0.03	76.45 ^e ±0.03	77.31 ^f ±0.03	76.22 ^h ±0.03
Dry Matter	90.73 ^a ±0.03	90.25 ^b ±0.03	89.16 ^f ±0.03	87.68 ^h ±0.03

Proximate	Cocoindia (M)			
	0	1	2	3
Moisture	9.82 ^h ±0.03	10.29 ^g ±0.03	10.26 ^g ±0.03	12.52 ^b ±0.03
Ash	3.94 ^d ±0.03	3.83 ^c ±0.03	3.74 ^f ±0.03	3.71 ^f ±0.03
Crude Protein	4.87 ^e ±0.03	4.17 ⁱ ±0.03	3.94 ^j ±0.03	3.93 ^d ±0.03
Crude Fat	1.03 ^a ±0.03	1.01 ^{ab} ±0.03	0.91 ^{bc} ±0.03	0.90 ^{cd} ±0.03
Crude Fibre	1.78 ^{cd} ±0.03	1.75 ^{de} ±0.03	1.69 ^{ef} ±0.03	1.64 ^f ±0.03
CHO	78.56 ^c ±0.03	78.95 ^b ±0.03	79.46 ^a ±0.03	77.30 ^f ±0.03
Dry Matter	90.18 ^c ±0.03	89.71 ^d ±0.03	89.39 ^e ±0.03	87.79 ^g ±0.03

Proximate	Anampu (M)			
	0	1	2	3
Moisture	9.79 ^h ±0.03	10.77 ^e ±0.03	10.80 ^{de} ±0.03	13.57 ^a ±0.03
Ash	4.15 ^b ±0.03	4.06 ^c ±0.03	3.90 ^d ±0.03	3.81 ^e ±0.03
Crude Protein	5.25 ^c ±0.03	5.13 ^d ±0.03	4.37 ^g ±0.03	4.27 ^h ±0.03
Crude Fat	0.94 ^{bc} ±0.03	0.91 ^{cd} ±0.03	0.88 ^{cd} ±0.03	0.86 ^d ±0.03
Crude Fibre	1.91 ^b ±0.03	1.83 ^c ±0.03	1.84 ^c ±0.03	1.84 ^c ±0.03
CHO	77.96 ^e ±0.03	77.30 ^f ±0.03	78.21 ^d ±0.03	75.65 ⁱ ±0.03
Dry Matter	90.18 ^c ±0.03	89.23 ^f ±0.03	89.22 ^f ±0.03	86.44 ⁱ ±0.03

Values are means of three independent determinations ±SD. Mean in the same row with the same superscript are not significantly ($p > 0.05$) different.

3.1.1. Moisture Content

Moisture contents of *achicha* varied significantly ($p < 0.05$) from 9.82 to 13.57%. The least moisture content occurred in *anampu* at zero month (9.79%) compared with the other samples analyzed which showed that they may have longer storage lives if packaged well and stored. The highest moisture content was observed in *anampu* at three months (13.57%). The low moisture contents of the three samples make them easy to store at room temperature and less prone to fungal and bacterial infections because food spoilage micro-organisms thrive where moisture content is very high, making them more shelf stable products. These findings agree with those of Aprianita *et al.* (2009) who reported the moisture content of cocoyam, yam and sweet potato to be 8.19, 10.51 and 7.07%, respectively. Hauwa *et al.* [20] also reported yam and cocoyam flours to be 9.85% and 10.99%, respectively. The moisture contents of all the samples increased as the storage period progressed. The microorganisms must have produced some moisture for metabolic activities. Sanni *et al.* [21] reported that the lower the moisture content of a product to be stored, the better the shelf stability of such product.

3.1.2. Ash Content

Ash is a reflection of the inorganic mineral elements present in the samples. Some of the samples investigated contained significant quantities of ash which differed significantly

($p < 0.05$) from each other. The values varied from 3.71 to 4.31%. The highest ash content occurred in *edeofe* at zero month, while the lowest ash content was observed in *cocoindia* after 3 months storage. However, the ash low levels could be attributed to the solubilization and leaching of nutrients into processing (cooking) water. Ash content in cassava reported by Eleazu and Eleazu [22] ranged from 1.44 to 2.35%.

3.1.3. Crude Protein

The mean values of crude protein varied significantly ($p < 0.05$) from 3.93 to 5.77%. The highest value of crude protein was found in *edeofe* (5.77%) at zero month and the least value was observed in *cocoindia* (3.93%) at 3 months. This study showed that crude protein content decreased with increase in storage time. This could be attributed to some reactions which might have occurred during storage. Ndabikunze *et al.* [23] reported crude protein of *Colocasia esculenta* (3.8g/100g) and *Xanthosoma sagittifolium* (4.75g/100g). Protein in diet helps primarily to build and maintain body cells. The protein content for all the samples tested was higher than those that have been reported in literature: 0.10-0.5% for yam starch [24, 25], 0.9-1.3% for taro starch [26] and 0.14-0.23% for sweet potato starch [27].

3.1.4. Crude Fat

The mean values of crude fat in *achicha* samples differed significantly ($p < 0.05$). Crude fat content varied from 0.86

to 1.05%. The least value occurred in *anampu* at three months, while the highest value was observed in *edeofe* at zero month. Fats are vital to the structure and biological functions of cells and are used as alternative energy source Eleazu and Eleazu [22]. Fat is also important to diet because it supplies essential fatty acids. Fats are vital to the structure and biological functions of cells and are used as alternative energy source. Ndabikunze *et al.* [23] reported that *Xanthosoma* and *Colocasia* varieties of cocoyam showed only low amount of fat expressed as ether extract (about 0.44 g/100g).

3.1.5. Crude Fibre Content

This study revealed that crude fibre contents varied significantly ($p < 0.05$) from 1.64 to 2.21%. The lowest value of crude fibre was observed in *cocoindia* at three months, while the highest value of crude fibre was found in *edeofe* at zero month. Previous studies showed that crude fibre content ranged from 1.53 to 2.31 for cocoyam varieties [23]. Crude fibre represents that portion of food not used up by the body but mainly made up of cellulose together with a little lignin and is known to increase bulk stool [28]. Crude fibre consists largely of cellulose and lignin (97%) plus some mineral matter. It represents only 60-80% of the cellulose and 4-6% of the lignin. The crude fibre content is commonly used as a measure of the nutritive value of poultry and livestock feeds and also in the analysis of various foods and food products to detect adulteration, quality and quantity.

3.1.6. Carbohydrate Content

The carbohydrate contents of the samples differed significantly ($p < 0.05$). The values ranged from 75.65 to 79.46%. The highest value of carbohydrate occurred in *cocoindia* at two months, while the least value of carbohydrate was observed in *anampu* at three months. Hauwa *et al.* [20] reported carbohydrate in yam flour (71.70%) and cocoyam (73.48%). The high content of carbohydrate in the corms agrees with the fact that tuber and root crops are generally rich in carbohydrate [20]. The reason for the observed difference in the carbohydrate may be partly attributed to the differences in their moisture content.

3.1.7. Dry Matter Content

The result of the dry matter contents varied significantly ($p < 0.05$) from 86.44 to 90.73%. The lowest value was observed in *anampu* at three months while the highest value was found in *edeofe* at zero month. Storage of these samples resulted to decrease in dry matter content. The microorganisms must have used up some dry matter for metabolic activities.

3.2. Proximate and Dry Matter Compositions of Mpoto During Three Months Storage

The results in Table 2 showed the comparison of Proximate Composition of *mpoto* processed from three different *Colocasia* varieties (*edeofe*, *cocoindia*, and *anampu*) stored from zero to three months interval.

Table 2. Proximate and Dry Matter Compositions (%) of Mpoto during Three Months Storage.

Proximate	<i>Edeofe</i> (M)			
	0	1	2	3
Moisture	8.23 ^k ±0.01	8.83 ⁱ ±0.00	9.27 ^e ±0.00	10.16 ^d ±0.00
Ash	15.34 ^c ±0.03	15.17 ^{ef} ±0.03	15.22 ^d ±0.03	14.31 ⁱ ±0.03
Crude Protein	16.83±0.03	16.34±0.03	15.28±0.03	15.19±0.03
Crude Fat	0.68 ^{cd} ±0.03	0.62 ^d ±0.03	0.94 ^a ±0.03	0.89 ^{ab} ±0.03
Crude Fibre	8.88 ^d ±0.03	8.37 ^e ±0.03	8.92 ^c ±0.03	8.74 ^e ±0.03
CHO	50.04 ^c ±0.03	50.69 ^b ±0.03	50.38 ^c ±0.03	50.72 ^b ±0.03
Dry Matter	91.77 ^a ±0.03	91.17 ^c ±0.03	90.74 ^c ±0.03	89.85 ^b ±0.03

Proximate	<i>Cocoindia</i> (M)			
	0	1	2	3
Moisture	9.04 ^b ±0.01	9.57 ^f ±0.00	10.09 ^e ±0.00	10.27 ^e ±0.00
Ash	16.17 ^a ±0.03	15.76 ^b ±0.03	15.14 ^f ±0.03	14.84 ^b ±0.03
Crude Protein	15.69±0.03	15.29±0.03	15.18±0.03	14.76±0.03
Crude Fat	0.73 ^c ±0.03	0.71 ^c ±0.03	0.83 ^b ±0.03	0.85 ^b ±0.03
Crude Fibre	9.13 ^a ±0.03	8.74 ^e ±0.03	8.66 ^f ±0.03	8.24 ^b ±0.03
CHO	48.94 ⁱ ±0.03	49.95 ^f ±0.03	50.11 ^d ±0.03	51.08 ^a ±0.03
Dry Matter	90.97 ^d ±0.03	90.43 ^f ±0.03	89.92 ^e ±0.03	89.74 ⁱ ±0.03

Proximate	<i>Anampu</i> (M)			
	0	1	2	3
Moisture	8.75 ⁱ ±0.01	9.26 ^e ±0.00	10.76 ^b ±0.00	11.36 ^a ±0.00
Ash	15.73 ^b ±0.03	15.28 ^{cd} ±0.03	15.29 ^c ±0.03	14.92 ^e ±0.04
Crude Protein	15.86±0.03	15.64±0.03	15.34±0.03	15.23±0.03
Crude Fat	0.64 ^d ±0.03	0.64 ^d ±0.03	0.84 ^b ±0.03	0.84 ^b ±0.03
Crude Fibre	9.18 ^a ±0.03	9.05 ^b ±0.03	8.82 ^d ±0.03	8.43 ^e ±0.03
CHO	49.84 ^e ±0.03	50.15 ^d ±0.03	49.96 ^f ±0.03	49.23 ^b ±0.03
Dry Matter	91.25 ^b ±0.03	90.74 ^c ±0.03	89.24 ^d ±0.03	88.67 ^k ±0.03

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



Figure 3. *Colocasia esculenta* Plant.



Figure 4. *Colocasia esculenta* corms/cormels.



Figure 5. Raw *achicha*.



Figure 6. *Colocasia esculenta* leaves.

3.2.1. Moisture Content

Moisture content of *mpoto* varied significantly ($p < 0.05$) from 8.23 to 11.36%. The moisture content of the samples was significantly ($p < 0.05$) different. The least moisture content occurred in *edeofe* (8.23%) at zero and first months, while the highest moisture content was observed in *anampu* (11.36%) at three months.

3.2.2. Ash Content

The samples investigated contained significant quantities of ash which differed significantly ($p < 0.05$) from each other. The values varied from 14.31 to 16.17%. The highest ash content occurred in *cocoindia* (16.17%) at zero month, while the lowest ash content was observed in *edeofe* (14.31%) at three months. Ash is a reflection of the inorganic mineral elements present in the samples. These values indicate that these vegetables species may be considered as good sources of minerals when compared to values (2 – 10%) obtained for cereals and tubers [29].

3.2.3. Crude Protein Content

The mean values of crude protein ranged from 14.76 to 16.83%. The mean value was significantly ($p < 0.05$) different. The highest value of crude protein was found in *edeofe* (16.83%) at zero month and the least value was observed in *cocoindia* (14.76%) at three months. This study showed that crude protein content decreased with increase in storage time. This could be attributed to changes in other proximate constants. Protein in diet helps primarily to build and maintain body cells. The protein content of *V. unguiculata* ($21.96 \pm 0.30\%$) was higher than that reported for some high value leafy vegetables such as *Momordica balsamina* (11.29%) and *Moringa oleifera* (20.72%) [30]. It's worth emphasizing that plant foods which provide more than 12% of their calorific value from proteins have been shown to be good source of proteins [31]. This suggests that *mpoto* leaves investigated are good sources of proteins and could play a significant role in providing cheap and available proteins for rural communities.

3.2.4. Crude Fat Content

The mean values of crude fat in *mpoto* samples differed significantly ($p < 0.05$). Crude fat content varied from 0.64 to 0.94%. The least value occurred in *anampu* (0.64%) at zero and first months, while the highest value was observed in *edeofe* (0.94%) at two months. Fats are vital to the structure and biological functions of cells and are used as alternative energy source [22].

3.2.5. Crude Fibre Content

This study revealed that crude fibre content ranged from 8.24 to 9.13% which were significantly ($p < 0.05$) different. The lowest value of crude fibre was observed in *cocoindia* (8.24%) at three months, while the highest value of crude fibre was found in *cocoindia* (9.13%) at zero month. The Crude fibres in these leafy vegetables would be advantageous for their active role in the regulation of intestinal transit, increasing dietary bulk due to their ability to absorb water.

3.2.6. Carbohydrate Content

The carbohydrate contents of the samples differed significantly ($p < 0.05$). The values ranged from 48.94 to 51.08%. The highest value of carbohydrate occurred in *cocoindia* (51.08%) at three months, while the least value of carbohydrate was observed in *cocoindia* (48.94%) at zero month. The reason for the observed difference in the carbohydrate may be partly attributed to the differences in their moisture content. The carbohydrate contents in this study were higher than 20, 23.7 and 39.05% reported for *Senna obtusifolia*, *Amaranthus incurvatus* and *Momordica balsamina* leaves, respectively [32]. These values are however; lower than those reported for *Corchorus tridens* (75%) and sweet potato leaves (82.8%).

3.2.7. Dry Matter Content

The result of the dry matter content varied significantly ($p < 0.05$) from 88.67 to 91.77%. The lowest value was observed in *anampu* (88.67%) at three months, while the highest value was found in *edeofe* (91.77%) at zero month. There were no significant ($p > 0.05$) difference among the samples. Storage of these samples resulted to decrease in dry matter content. This could be attributed to some reactions which might have occurred during storage. The microorganisms must have used up some dry matter for metabolic activities.

4. Conclusion and Recommendations

4.1. Conclusion

This study showed the effect of processing and storage on the *Colocasia* based products (*achicha* and *mpoto*). *Achicha* is nutritionally rich in carbohydrates. However, its composition varies according to the variety. *Mpoto* leaves examined have high contents of ash, crude protein, crude fibre with low fat content and carbohydrate. All these results suggest that the studied leaves if consumed in sufficient amount would contribute greatly to the human nutritional requirement for normal growth and adequate protection against diseases arising from malnutrition.

4.2. Recommendation

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. Further studies should be carried out on the effect of storage on these cocoyam-based products.

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