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Effect of Storage Period and Variety on the Phytochemical Properties of Stored Cocoyam-Based Products

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Abstract: The effects of storage life and variety on the phytochemical properties of stored cocoyam-based products were studied. A-5 kg of corms was sorted, cleaned, and cooked for three hours. After cooling down, they were peeled and sliced with a sharp kitchen knife into tiny pieces, measuring an average of 2.0 by 1.5 cm. The sample was dried in the oven at 55 °C for 6 hours and milled using a mechanical blender. A-300 grams of cocoyam leaves were harvested, sorted, cleaned, and the sample was dried in the oven at 55 °C for 6 hours and milled using a mechanical blender. The samples were kept apart in plastic containers for 0, 1, 2, and 3 months. With SPSS version 23, the collected data were statistically examined. Fisher's Least Significant Differences was used to separate the means at $p \leq 0.05$. After three months in storage, the following were the phytochemical characteristics of achicha (mg/100g): alkaloid (1.24, 1.19, 1.38); tannin (0.67, 0.71, 0.75); saponin (1.27, 1.35, 1.43); flavonoid (0.39, 0.34, 0.46); polyphenol (1.27, 1.25, 1.31); oxalate (2.56, 2.27, 2.67); and phytates (1.66, 1.42, 1.46) for edeofe, cocoindia, and anampu, respectively. After three months of storage, the phytochemical characteristics of mpoto (mg/100g) were as follows: alkaloid (1.62, 1.52, 1.72); tannin (1.74, 2.17, 1.91); saponin (1.72, 1.79, 1.67); flavonoid (0.60, 0.74, 0.66); polyphenol (1.48, 1.53, 1.38); oxalate (1.66, 1.60, 1.49); and phytates (1.75, 1.71, 1.63) for edeofe, cocoindia, and anampu, separately. The cocoyam corms and leaves may be helpful in food preparation and the treatment of certain chronic diseases, given the significant concentrations of health-promoting phytochemicals found in processed cocoyam *achicha* and *mpoto* samples.

Keywords: Achicha; mpoto; alkaloid; tannin; polyphenol.

1. Introduction

All the naturally occurring substances found in fruits, vegetables, legumes, grains, and tubers that contribute to a plant's color, flavor, and aroma, as well as its inherent ability to fend against disease, are known as phytochemicals. Onyeka [1] states that phytochemicals are plant compounds found in fruits, vegetables, grains, and other plant foods that are bioactive but not nutrients. These compounds have been shown to lower the risk of major degenerative diseases in humans. Plant-based compounds known to carry out several physiological tasks, such as antioxidant activities in humans, are called

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phytochemicals [1]. Phyto-medicine, another name for herbal medicine, is based on medicinal plants, including herbs, roots, and tubers, as well as fruits [2,3].

According to Nirumand et al. [4], fruits and plants have also long been used in traditional medicine, despite the popularity of herbs, roots, their stems, rhizomes, and barks. Medicinal fruits fulfill a dual role as both nutritional and curative foods; for this reason, they are also known as functional foods or nutraceuticals [5,6]. Fruits, vegetables, nuts, roots, and tubers all contain phytochemicals that may help slow down aging and lower the risk of several illnesses, such as cancer, heart disease, stroke, high blood pressure, osteoporosis, and urinary tract infections [7]. Researchers are excited to re-examine every plant using a fresh perspective on how they might be used as food or medicine. Secondary metabolites like phenols, flavonoids, tannins, alkaloids, terpenoids, lignin, quinones, coumarins, and amines are the best antioxidants. In contrast, primary metabolites such as carbohydrates, proteins, vitamins, sterols, and lipids are found in plants and provide food with its nutritional value [8].

Originating from the *Araceae* family, which includes about 2000 species and 110 genera, including essential species like *Colocasia*, *Xanthosoma*, *Amorphallus*, and *Cytosperma*, cocoyams are aroids grown mainly for their edible corms. *Colocasia*, *Alocasia*, and *Xanthosoma* are members of the tribe; *Colocasia* is a member of the *Colocasinae* sub-tribe, while *Xanthosoma* is a member of the *Caladinae* sub-tribe. The *Araceae* family is cultivated in many tropical and subtropical nations. It has been recognized as a significant underutilized root crop group with an uncertain future due to low demand, which could result in decreased production until it becomes a minor niche crop [9]. According to Ogundare-Akanmu et al. [10], *Colocasia esculenta* and *Xanthosoma sagittifolium*, also known as cocoyam, are two of the six most significant tuber roots in the world. They are herbaceous perennial plants that belong to the *Araceae* family. Based on research by David-Chukwu et al. [11], cocoyam, or *Colocasia esculenta* Linn (*Araceae*), is a tropical perennial starchy plant native to Asia and the Pacific.

This suggests that consuming products made from the Colocasia species may offer health benefits. The corm of *Colocasia esculenta* roots contains a high concentration of β-carotene, which gives the body antioxidant and vitamin A properties. The structural differences between β-carotene are negligible. They are widely distributed carotenoids with additional possible health benefits. They are also antioxidants. Alkaloids are secondary metabolites found in medicinal plants that may have anti-bacterial properties [12]. A high concentration of alkaloids in roots, tubers, and corms can cause toxicity, bitterness, and/or itching. Due to their potent antioxidant properties, flavonoids are thought to impede the progression of cataracts in diabetics [13].

Tannins function as antioxidants by reducing oxidative stress, which is a known cause of inflammation, certain cancers, and coronary heart disease. Phenolic chemicals known as tannins interact with proteins. They negatively impact feed intake and have an astringent effect. Tannins mainly cause complex formation, which is difficult to digest, by precipitating or binding dietary proteins and digestive enzymes. This is how they exert their anti-nutritional effect. Because tannins form complexes with proteins, they also inhibit the activities of some enzymes, including lipase and amylase. Protein from food is less tannin-rich after processing [14].

Chronic calcium deficiency is thought to be brought on by eating foods high in oxalate. When consumed with foods high in oxalate, oxalate often forms an insoluble complex with calcium ions, disrupting calcium metabolism. According to Bello et al. [15], phytic acid limits the availability of several essential minerals, including calcium, magnesium, and iron. Additionally, the removal of phosphorus from the human body, as well as indigestion and flatulence, has been linked to phytic acid. Because phytates bind to vital minerals (such as iron, calcium, zinc, and magnesium) in the digestive tract, they decrease the availability of these minerals in food. This can lead to mineral deficiencies. It is known that foods high in phytate limit the activity of multiple enzymes and reduce the bioavailability of minerals. Some essential minerals, like calcium, iron, and magnesium, are less available when exposed to phytic acid. Additionally, the removal of phosphorus from the body has been linked to flatulence and indigestion in humans [7].

Acute poisoning is not common, but a high amount of saponin is linked to gastroenteritis, which manifests as diarrhea and dysentery, according to Bello et al. [15]. Flavonoids are well-known for their antioxidant properties, their ability to prevent oxidative cell damage, their strong anticancer activity, and their protection against all stages of carcinogenesis [13]. Flavonoids exhibit strong anticancer activity, protect against all stages of carcinogenesis, and prevent oxidative cell damage [15]. These are simple

phenolic acids that are widely distributed in plant cell walls and, as a result, constitute important parts of the human diet. Their antioxidant activity has been extensively researched; however, these studies have primarily been conducted in vitro, and more research on the effects of these substances in humans is needed before any health benefits can be asserted. A taro cultivar with yellow flesh has a high level of total phenolic compounds.

The anti-nutrients in taro corms have both beneficial and harmful effects on taro as a food crop. They also have a positive impact on taro, a crop that can be grown with minimal use of pesticides or fungicides. According to Ramanatha et al. [16], the main anti-nutrients found in taro include mucilage, oxalic acid, tannin, cyanide, lectins, alpha-amylase inhibitors, protease (chymotrypsin and trypsin), and inhibitors. Moreover, phytic acid has been linked to phosphorus removal, flatulence, and indigestion in the human body. Due to their known ability to bind certain minerals (such as zinc, calcium, magnesium, and iron) in the digestive tract and cause mineral deficiencies, a high phytate content in the sample may limit the availability of vital minerals in the food [15].

After undergoing various heat treatments like boiling, blanching, steaming, baking, roasting, stewing, frying, and pressure cooking, people typically consume the corms and leaves of taro. These techniques work well for reducing anti-nutritional factors, boosting nutrient bioavailability, and enhancing food safety. The phytochemical and anti-nutrient contents of taro corms are affected by processing. According to Soudy et al. [17], there will be a further decrease in taro corm powder when it is processed into cookies and noodles. Therefore, to maintain nutrients and deactivate anti-nutritional factors, a combination of cooking time and temperature program is required. Cooking, on the other hand, raises the levels of crude fat, crude protein, crude fiber, and antioxidant activity. Due to its high fiber content, cooking can help manage non-communicable diseases like cancer, diabetes, heart disease, high blood pressure, obesity, and gastrointestinal disorders [17].

One of the primary issues with taro is that, after harvesting, the corms are often vulnerable to physical damage, increasing post-harvest losses. A straightforward method for making flour from the roots of *Colocasia esculenta* has been established by certain recent studies. During this procedure, the roots are cooked while still in their skins, then peeled, sun-dried, and ground through 500 μm sieves [18]. According to Chinnajarn et al. [19], processed taro flour can be used in baked goods, infant foods, biscuits, pasta, and other food formulations.

This study's primary goal is to assess how storage duration and variety affect the phytochemical composition of cocoyam products. The work's particular goals are to produce dried cocoyam corms/cormels or *achicha*, and dried cocoyam leaves, or *mpoto*, and to ascertain the phytochemical composition of both after three months of storage. Cocoyam post-harvest losses can be decreased, small-scale farmers can find a market, and the uses of cocoyam can be expanded by processing its leaves and corms into more shelf-stable dry products like *achicha* and *mpoto*. Producers and consumers of *achicha* and *mpoto* products would feel more confident after these products' phytochemical properties were assessed.

2. Materials and Methods

2.1. Collection of Materials

The National Root Crop Research Institute, Umudike, Abia State, provided the fresh cocoyam corms/cormels and leaves (*edeofe*, NCE 002), *cocoindia*, NCE 001, and *ukpong/anampu*, NCE 004). The agronomist at the National Research Institute, Umudike, Cocoyam Unit, Abia State, identified the fresh samples. Figures 1 display the cocoyam (*Colocasia esculenta*), corms/cormels, and leaves.

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

For each sample, 5 kg of cocoyam corms or cormels were sorted, cleaned, and cooked for 3 hours. With a sharp kitchen knife, it was cooled, peeled, and cut into small pieces, measuring an average of 2.0 cm by 1.5 cm. The sample was dried in the oven at 55 °C for 6 hours in a hot air oven (model: KZ 760 4SS China) and milled using a mechanical blender (model: BLG-595(MK2) China) according to the method of Enyi et al. [20] and stored in an airtight container for three months. The samples were examined at zero, one, two, and three-month intervals. Figures 1 and 2display images of the cocoyam

plant, its corms/cormels, leaves, and processed achicha, in that order. Also, the flow chart of the production of achicha from cocoyam corms/ cormels is shown in Figure 2 [11].

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

A 300 g sample of cocoyam leaves was taken, sorted, cleaned, dried in the oven at 55^{o}C for 6 hours in a hot air oven (model: KZ 760 4SS China) and milled using a mechanical blender {model: BLG-595(MK2) China} according to the method of Enyi et al. [20] and stored in air tight container for three months. The leaves were examined at zero, one, two, and three months. Figures 2 and 3depict the flow chart that details the steps involved in preparing the *achicha* and *mpoto* samples, respectively.

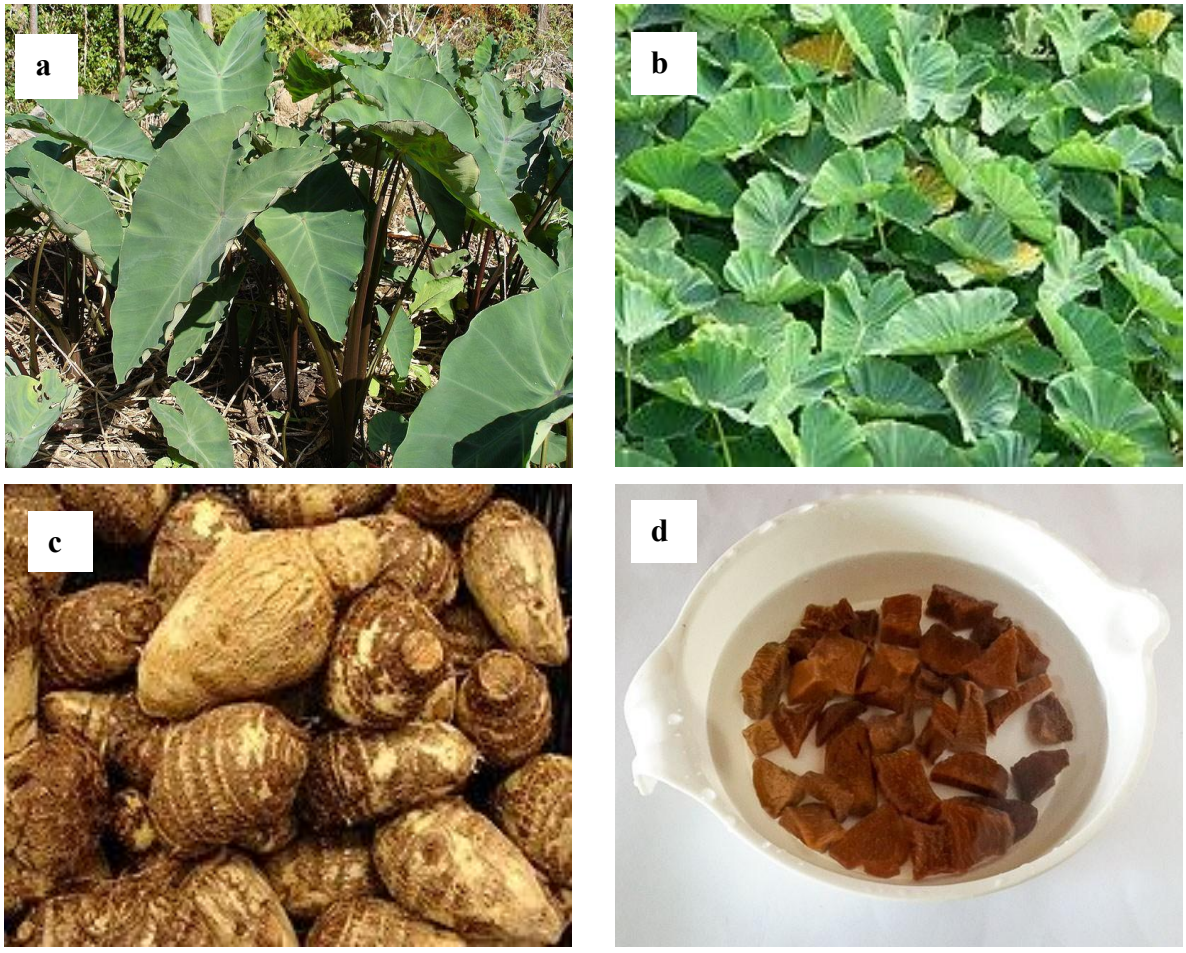

Figure 1. a) *Colocasia esculenta* Plant, **b**) the leaves, **c**) the corms/cormels, **d**) Raw *achicha*

2.4. Phytochemical Analysis

The plant material was subjected to this analysis utilizing Obadoni and Ochuko [21] method.

2.5. Determination of Alkaloid Content

Harbone's [22] alkaline precipitation gravimetric method was used to accomplish this. Five grams of the ground samples were measured and put into individual 250 ml beakers. 200 ml of 20% acetic acid in ethanol (1:10) was then added, and the beaker was covered and left to stand for four hours. After filtering, the extract was treated by adding concentrated aqueous NH_4OH dropwise until the alkaloid precipitated. The extract was then concentrated by evaporation in a water bath to one-quarter of its original volume. After the entire mixture had settled, the precipitate was filtered, dried, and weighed.

$$\% \text{ Alkaloid} = \frac{Weight of Residue}{Weight of Sample} \times 100$$

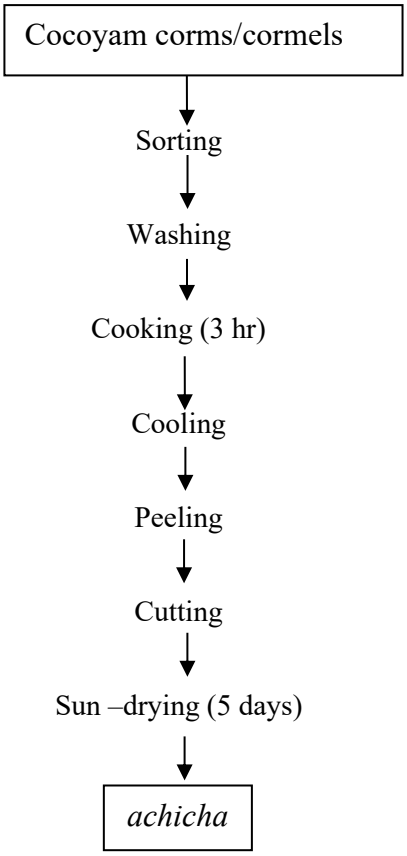

Figure 2. The flow chart of the production of *achicha*

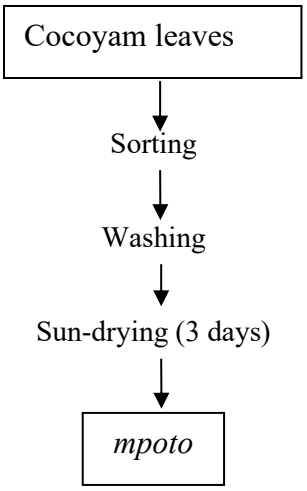

Figure 3. The flow chart of the production of *mpoto*

2.6. Determination of Tannin Content

Five grams of the sample were weighed and placed in a 100-milliliter plastic bottle. Each sample received about 50 milliliters of distilled water, and it was shaken for an hour in a mechanical shaker. After filtering, it was added to a 50 ml volumetric flask and diluted to the desired level with distilled water. Next, 3 ml of 0.1 M $FeCl_3$ in 0.1 N HCl and 0.008 M potassium ferrocyanide were combined with 5 ml of the filtrate pipetted into each tube. In 10 minutes, the absorbance was measured at 760 nm in a spectrophotometer. Using the extraction solution (distilled water), a blank sample was created. Okechukwu and Ogah [7] reported that a standard absorbance measurement was conducted at 760 nm using a tannic acid solution (5 mg/ml) and a blank reagent at zero absorbance.

$$\%\text{Tannin} = \frac{100 \times A_u \times C \times V_f \times D_f}{W \times A_s \times 1000 V_a}$$

Where, A_u=Absorbance of sample, A_s=Absorbance of standard tannic acid, C=Concentration of standard tannic acid in mg/L, W=Weight of sample analyzed, $D_{f.}$= Dilution factor where applicable, $V_{f.}$=Volume of the filtration, V_a=Volume of the filtrate analyzed.

2.7. Determination of Saponin Content

The ground samples were diluted with 200 milliliters of 20% ethanol to a weight of five grams. Over 4 hours, the suspension was continuously stirred at 55 °C in a hot-water bath. Following filtration of the mixture, 200 milliliters more of 20% ethanol were used to extract the residue once more. A hot water bath at 90 degrees Celsius was used to reduce the combined extracts to 40 milliliters. Twenty

milliliters of diethyl ether were added to the concentrated extract, which was then transferred into a 250-milliliter separation funnel and vigorously shaken. The ether layer was disposed of, and the aqueous layer was recovered. Following another round of purification, 60 ml of N-butanol was added, and the combined N-butanol extracts were washed twice with 10 ml of 5% aqueous sodium chloride. Ten milliliters of 5% aqueous sodium chloride was used to clean the residual solution twice. The residual mixture was transferred into a desiccated, previously calibrated crucible and baked at 60 °C until a consistent mass was reached [7].

$$\%\text{Saponin} = \frac{W_{2-}W_1}{W} \times 100$$

Where, W=Weight of sample, W_1=Weight of empty crucible, W_2=Weight of crucible and saponins.

2.8. Determination of Flavonoid Content

After weighing five grams (5 g) of each sample into a beaker, the samples were extracted for thirty minutes at room temperature using 55 cm^3 of ethanol. The contents of a 100 ml flask were filtered through Whatman No. 42 filter paper. After being moved into a crucible dish, the filtrate was dried in a desiccator oven for 30 minutes at 60 °C. Uzoukwu et al. [23] reported that the content and the crucible were weighed and recorded.

$$\%\text{Flavonoid} = \frac{W_2-W_1}{W} \times 100$$

Where, W=Weight of the sample used, W_1=Weight of dried evaporating dish, W_2=Weight of evaporating dish + Flavonoid.

2.9. Determination of Polyphenols Content

The spectrophotometer was used to determine this [24]. Each sample was extracted with 10 mL of concentrated methanol to obtain 200 mg of total phenols. At room temperature, the mixture was shaken for 30 minutes. The mixture was centrifuged for 15 minutes at 5000 rpm, and the extract (supernatant) was used for analysis. One milliliter of each sample's extract was treated with an equal volume of Folin-Ciocalteu reagent, and then 2 milliliters of a 2% Na_2O_3 solution were added. In the meantime, a standard phenol solution was made and diluted to the appropriate concentration. The F-D reagent and Na_2O_3 solution were also applied to about 1 milliliter of the standard solution. Using a reagent blank set to zero, the absorbance of the resultant blue coloration was measured in a spectrophotometer at 560 nm. The following formula was used to determine the phenol content [8].

$$\%\text{Phenol} = \frac{100 \times A_u \times C \times V_t}{W \times A_s \times V_a}$$

Where, W=Weight of sample, A_u=Absorbance of test sample, A_s=Absorbance of standard phenol sample, C=Concentration of standard phenol sample, V_t=Total extract volume, V_a=Volume of extract analyzed.

$$Inhibition\ (\%) = 100 - (\frac{OD\ test\ well}{OD\ control}) * 100$$

2.10. Determination of Oxalate

This was completed in compliance with AOAC [24]. Each sample was weighed to 2 g, and 20 mL of 0.3 M HCl was added twice at 50 °C, and the mixture was stirred for 1 hour. To estimate total oxalate, the combined extract was diluted to 100 milliliters with distilled water. 5 ml of the extract, which had been made alkaline with 1 ml of 5 M ammonium hydroxide, were pipetted to estimate the oxalate content. Next, three drops of phenolphthalein and a drop of acetic acid were added to the extract. After adding about 1 ml of 5% $CaCl_2$ (aq.) to the mixture, it was centrifuged for 15 minutes at 3000 rpm and left to stand for two hours. The precipitates were thoroughly mixed and centrifuged three times after the supernatants were disposed of. After adding two milliliters of 3 M H_2SO_4 to the test tube, the precipitate was dissolved by heating it in a water bath at 75 °C. After that, the contents of the test tube

were filtered using a freshly prepared 0.01 M $KMnO_4$ solution at room temperature until the solution began to turn pink. After warming to 75 °C, the titration was repeated until the pink color persisted [23].

$$\%\text{Oxalate} = \frac{V_t \times V_{me} \times Titre}{V_s}$$

Where, V_t=Total volume of titrate = 100, W=Weight of the sample g, V_{me}=Volume = mass equivalent (i.e., 1 cm^3 of 0.05M $KMnO_4$is equivalent to 2.25 mg anhydrous oxalic acid).

2.11. Determination of Phytate

In compliance with AOAC [24], this was done. Each sample weighed two grams, and 10 milliliters of distilled water were added to each test tube. A glass-stoppered test tube held 0.5 ml of the extract, which was pipetted into it after the sample was extracted with 2 ml of 0.2 N HCl (aq.). A stopper was placed over the tube after 1 milliliter of the solution was added. For 15 minutes, the stopper was securely sealed over the entire length of the tube while it was heated in a boiling water bath for 30 minutes. The solution-filled test tube was then allowed to reach room temperature after chilling in ice water for 15 minutes. A thorough mixing of the test tube contents was followed by 30 minutes of centrifugation. In a new test tube, 1.5 ml of the solution was added after 1 ml of the supernatant was transferred. In comparison to distilled water, the absorbance at 420 nm was measured.

$$\%\text{Phytate} = \frac{A_u \times C \times 100 \times V_f}{A_s \times W \times V_A}$$

Where, Au =Absorbance of test sample, As=Absorbance of standard solution, C=Concentration of standard solution, W=Weight of sample used, V_f=Total volumes of extract, V_a=Volume of extract.

2.12. Statistical Analysis

The acquired triplicate data were statistically analyzed using SPSS software, version 23. Once the mean values were established, Fisher's Least Significant Difference was used to separate the means ($p \leq 0.05$) using one-way ANOVA.

3. Results and Discussion

3.1 Phytochemical Composition (%) of Achicha During Three Months of Storage

The comparison of the mean phytochemical composition of three distinct *Colocasia* varieties (*edeofe*, *cocoindia*, and *anampu*) of processed *achicha* that was stored for three months is displayed in Table 1.

3.1.1. Alkaloid Content

The levels of alkaloids varied considerably ($p<0.05$), ranging from 1.19 to 1.63%. *Anampu* (1.63%) had the highest alkaloid content at zero months, while *cocoindia* (1.19%) had the lowest alkaloid content at three months of storage. The impact of heat applied during processing and storage may be responsible for the notable ($p<0.05$) decline in alkaloid content of *achicha*. Table 1 illustrates that the varieties with comparatively lower levels of alkaloids after three months of storage were *edeofe* (1.24 mg/100g), *cocoindia* (1.19%), and *anampu* (1.38%). It is noteworthy that alkaloids are typically non-toxic at the concentrations found in edible plants because boiling lowers their levels (<20 %) in plant extracts, which could result in fatal illnesses [23,7]. Because heat was applied during this work, *achicha* samples are safe to eat. Consequently, this study supports the claims of traditionalists that *cocoyam*, when roasted over fire, can be applied to injured body parts or foot sores infected by earthworms. It may also have a positive effect on the healing of wounds and be an effective treatment for ulcerations [7].

3.1.2. Oxalate Content

The results (Table 1) indicated that the samples of *achicha* had oxalate contents ranging from 2.27 to 3.04%. The samples with the highest and lowest oxalate contents, respectively, were from *Anampu* (3.04 %) and *Cocoindia* (2.27%). The *achicha* samples were significantly ($p<0.05$) different

from one another. Table 1 indicates that after three months of storage, the oxalate contents of all three varieties-*edeofe* (2.56 mg/100g), *cocoindia* (2.27%), and *anampu* (2.67%) were comparatively low. Given that oxalate and calcium ions can form an insoluble complex, it is common knowledge that eating foods high in oxalate can affect how calcium is metabolized. The lethal dose of oxalate is 15–30 g, according to the Environmental Health and Safety, U.S.A. Below this fatal dosage, the oxalate levels in all *achicha* samples, regardless of variety, were lower [7]. Since toxicosis can result from soluble oxalate concentrations of 2% or higher, this level is within the safe range [23]. Hence, they are considered benign when detected at trace levels, as shown in Table 1. The oxalate content may have decreased during the various steps involved in producing *achicha* before sun-drying, including washing, cooking, peeling, and cutting. While washing reduced the oxalate concentration by 9.2%, Huang et al. [25] reported that tuber peels contain more oxalate than peeled tubers. Akpan and Umoh [26] reported similar findings in their study. Different processing methods can reduce the acridity of high-oxalate cocoyam cultivars, according to Buntha et al. [27]. According to Alcantara et al. [28], boiling can induce significant cell rupture, making it easier for soluble oxalate to seep into the baking water.

3.1.3. Phytates Content

The amount of phytates in 100g varied significantly (p<0.05) from 1.42 to 1.77%. According to Table 1, *edeofe* had the highest phytate content (1.63%) at zero months, while *cocoindia* had the lowest (1.42%) at three months. Several essential minerals, including magnesium, zinc, iron, and even calcium, are less accessible due to phytic acid [29]. Okechukwu and Ogah [7] speculate that leaching (soaking) and thermal processes (cooking and drying) may be to blame for the notable decrease in the phytate content of the *achicha* samples. Mineral deficiencies caused by phytate make it easier for toxic metals to replace necessary minerals, such as zinc by cadmium and iron by lead [30]. According to Kalu et al. [30], in third-world countries where plant-based diets are the norm, phytates are the leading cause of poor growth, anemia, immune system incompetence, and other health problems. Consequently, only by discarding the boiling water does the phytate content of the water decrease. The amount of phytate in achicha samples gradually decreased when heated for extended periods at high temperatures [28].

3.1.4. Saponin Content

According to the results, the *achicha* samples' saponin contents ranged from 1.27 to 1.71%. The *anampu* sample, which was taken at zero months, had the highest saponin content (1.71%), while the *edeofe* sample, taken at three months of storage, had the lowest (1.27%). There was a significant (p<0.05) difference between the samples. According to Senanyake et al. [31], *X. sagittifolium* contains 13.11% saponins. The lower values reported in this report may be due to the soaking, cooking, and sun-drying processing techniques. Elevated levels of saponin have been linked to gastroenteritis, which is characterized by diarrhea and dysentery; however, acute poisoning is not frequently observed. Glycosides known as saponins include triterpenoid and steroid saponins. Elevated levels of saponins in feed affect chicken growth rate and feed intake. Reduced feed intake has been attributed to both the irritating and bitter tastes of saponins [23]. Okechukwu and Ogah [7] claim that saponin can enhance immune response. Both vaccinations and spermicides contain saponin. It has been reported that saponins possess anti-microbial and anti-viral properties, in addition to their ability to inhibit the growth of both benign and malignant tumors. According to Okechukwu and Ogah (2023), saponins are crucial for maintaining hormonal balance and for the synthesis of sex hormones.

3.1.5. Flavonoid Content

The findings indicated that the *achicha* samples had flavonoid contents ranging from 0.34 to 0.71%. The flavonoid content of the *Anampu* sample was 0.71% at zero months, while the *edeofe* sample had 0.34 mg/100g at three months of storage. There was a significant difference (p<0.05) between the samples. Senanyake et al. [31] reported that *X. sagittifolium* had a flavonoid content of 11.30%. Polyphenolic substances called flavonoids exhibit biological activity against microbes, tumors, inflammation, and free radicals, as well as against liver toxins [32]. Flavonoids are valuable resources that can be added to food products. They can neutralize free radicals and halt their chain reactions in biological systems, suggesting they play a significant role in reducing the risk of chronic disease. Because they can function as natural antioxidants in food, flavonoids are highly substantial [7]. By

suppressing lipoxygenase activity, they not only prevent lipid autoxidation but also delay lipid oxidation. They are helpful in vivo in lowering the risk of cardiovascular diseases and related disorders because they function as chelators of metal ions, scavengers of reactive oxygen species, and electrophiles *in vitro* [7].

3.1.6. Polyphenol Content

The levels of polyphenols in food varied considerably (p<0.05), ranging from 1.25 to 1.53%. *Anampu* had the most excellent polyphenol content (1.53%) at zero months of storage, while *cocoindia* had the lowest (1.25%) at three months. Since prolonged exposure to high temperatures reduces polyphenol content in achicha samples, the lower values reported here may be due to processing techniques such as cooking and sun-drying [7]. Polyphenol oxidase can be denatured at high temperatures, and the combination of a longer cooking time and a higher temperature promotes further cell disruption and phenolic compound breakdown. There have also been reports that a significant decrease in polyphenol may result from increased and/or prolonged thermal treatment, such as boiling, cooking, and sun-drying, since most of these compounds are relatively unstable compared to certain heat-stable ones [28].

3.1.7. Tannin Content

The findings indicated that the *achicha* samples had tannin contents ranging from 0.67 to 1.14%. The tannin content of the *Anampu* sample at zero months was the highest (1.14%), while the *edeofe* sample at three months of storage had the lowest (0.67%). There was a significant difference (p<0.05) between the samples. According to reports, tannins have anticarcinogenic and antihelminthic properties [33]. On the other hand, studies indicate that increased tannic acid consumption has been linked to poor protein utilization as well as toxicity to the liver and kidneys [30]. The best processing techniques for reducing cocoyam tannin content are cooking and sun-drying, even though none of the processed achicha samples showed higher tannin levels. Higher tannic acid intake has reportedly been linked to poor protein utilization, liver and kidney toxicity, and carcinogenic effects in humans. Bitter polyphenolic compounds called tannins accelerate the healing process. Additionally, they have antidiuretic and antidiarrheal properties. According to reports, tannin can specifically prevent HIV replication [7].

From the findings of this study, it was observed that as the storage period increased from 0 days through 1, 2, and 3 months, the phytochemical contents of the samples decreased. This could be as a result of enzyme activity. Phytochemicals are broken down by oxidative enzymes that were not fully inactivated during processing.

3.2. Phytochemical Composition (%) of Mpoto During Three Months of Storage

The mean phytochemical composition of *mpoto* processed from three distinct *Colocasia* varieties (*edeofe*, *cocoindia*, and *anampu*) stored for 3 months is shown in Table 2.

3.2.1. Alkaloid Content

Alkaloid contents ranged from 1.52 to 1.85%, with a significant difference (p<0.05). At zero months, *anampu* had the highest alkaloid content (1.85%), while at three months, cocoindia had the lowest alkaloid content (1.52%). According to Senanayake et al. [31], the alkaloid content of *X. sagittifolium* flour was 0.99%. Alkaloids are helpful compounds that can repel parasites and predators. But they also prolong the action of cyclic AMP by inhibiting certain mammalian enzymatic activities, such as phosphodiesterase [23]. In addition, they have an impact on thyroid-stimulating hormones and glucagon, and some of their forms have been linked to cancer [34]. Interestingly, because thermal processing lowers the amounts of alkaloids in plant extracts, they are typically non-toxic at the concentrations found in edible plants. According to Obueh and Kolawole [35], alkaloids are a broad class of nitrogenous compounds that are frequently used as cancer chemotherapeutic agents. However, they also impede cell division and almost always cause food to taste bitter.

The leaching process and the heat application were blamed for the decrease in the mpoto samples' alkaloid content. Alkaloids are thought to have evolved in plants as a means of protection against

predators, helping plants survive. According to Okechukwu and Ogah [7], alkaloids have a wound-healing effect on animals.

3.2.2. Oxalate Content

The findings in Table 2 indicate that the oxalate content of the mpoto samples ranged from 1.49 to 1.81%. In terms of oxalate content, edeofe had the highest value (1.81%) at zero months of storage, while *anampu* had the lowest value (1.49%) at three months. There was a significant difference (p<0.05) between the samples. The primary substances that restrict the application of cocoyam leaves are oxalates and oxalic acid. When present in raw or unprocessed foods, they impart a strong taste or irritate the stomach [36]. Calcium oxalate crystals, which pierce soft skin and resemble needles or raffia, are the source of this strong taste and stiffness. Then, the reef-found irritant, possibly a protease, may make tissue uncomfortable [37]. This oxalate concentration is safe because toxicosis can occur at soluble oxalate concentrations of 2% or higher. Consequently, as Tables 1 and 2 demonstrate, they are deemed innocuous in small concentrations. Oxalate levels in *mpoto* samples are therefore safe, especially considering that heat has been shown to significantly reduce the total oxalate content of plants [23]. According to Kalu et al. [30], cooked vegetables or leaves have a much lower total oxalate content when properly prepared for consumption.

3.2.3. Phytate Content

Table 2 shows that phytate levels varied significantly (p<0.05), ranging from 1.63 to 1.91%. Regarding *mpoto*, *anampu* had the lowest phytate content (1.63%) at three months of storage, while *edeofe* had the highest (1.91%) at zero months. Kalu et al. [30] found that the amount of phytates in the inflorescence of cocoyam was lower than that of many plant leaves that are generally regarded as safe to eat, such as fluted pumpkin (38.4%), cowpea leaves (45.5%), and *Ocimum canum* (41.27%). Thus, as this study indicated, *mpoto* samples may be safer to eat than these leaves. Further evidence that phytates may be soluble at extremely high temperatures, such as those experienced during washing and sun-drying, comes from the notable decrease in phytate content in *mpoto* samples [28,29].

3.2.4. Saponin Content

The findings presented in Table 2 demonstrated that the *mpoto* samples' saponin content ranged from 1.67 to 1.93%. At zero months, the *cocoindia* sample had the highest saponin content (1.93%), while the *anampu* sample had the lowest saponin content (1.67%) after three months of storage. The samples differed statistically significantly (p<0.05). High levels of saponins impact poultry growth rate and feed intake. The bitter taste of saponins and their irritant effect have been linked to decreased feed intake [38]. Hypocholesterolemia is caused by excess saponins, which bind cholesterol and prevent its absorption. Reduced protein digestibility may result from the formation of a saponin-protein complex [38]. Elevated saponin concentrations slow down an animal's growth rate and hemolyze red blood cells. Additionally, saponins possess antioxidant, anti-tumor, and cholesterol-lowering effects. A carbohydrate moiety is affixed to a triterpenoid or steroidal aglycone in saponins [39]. Saponins inhibit the intestinal absorption of glucose and cholesterol via intraluminal physicochemical interactions. According to Ifemeje [34] and Uzoukwu et al. [23], this may provide users with chemo-protection against heart diseases. Saponin has anti-inflammatory and anticancer properties, despite being non-toxic, due to its cytotoxic effects and growth-inhibitory effects against a range of cells [30].

3.2.5. Flavonoid Content

The results in Table 2 demonstrated that the *mpoto* samples' flavonoid content varied from 0.60 to 0.87%. After three months of storage, the *edeofe* sample had the lowest flavonoid content (0.60%), while the *cocoindia* sample had the highest flavonoid content (0.87%). There was a significant (p<0.05) difference between the samples. Fruits, vegetables, grains, bark, roots, stems, flowers, tea, and wine all contain flavonoids, a class of naturally occurring compounds with varying phenolic structures. In today's nutraceutical, pharmaceutical, medical, and cosmetic applications, flavonoids are regarded as essential components. The flavonoids are categorized into different classes as alkaloids, terpenoids, and phenolics. According to Kumar and Pandey [40], flavonoids perform a variety of defensive roles in the human body. Numerous flavonoids have evolved into bioactive compounds that interact with proteins

or nucleic acids and exhibit pharmacological, insecticidal, and antimicrobial properties [41]. The anti-inflammatory, antioxidant, anti-allergic, hepatoprotective, antithrombotic, antiviral, and anticarcinogenic properties of flavonoids have been reported [40]. Therefore, flavonoids are interesting as therapeutics in medicine and as pesticides in agriculture. According to Panche et al. [41], *in vitro* technology has provided new insights into the ability of plant cell tissue culture to produce the same valuable chemical compounds as the parent plant. While it's too soon to recommend daily flavonoid intakes, it is advised to consume *mpoto*, which contains flavonoids. Additionally, it has been noted that flavonoids prevent diabetic patients' cataracts from growing [7].

3.2.6. Polyphenol Content

Polyphenol concentrations ranged from 1.38 to 1.71%, with a significant difference ($p<0.05$). At zero months, *cocoindia* had the highest polyphenol content (1.71%), while *anampu* had the lowest (1.38%) at three months of storage. Certain phytonutrient levels were present in cocoyam leaves (*mpoto*), but these levels degrade over time when stored at room temperature. Polyphenol oxidase can be denatured at high temperatures, and the combination of a longer cooking time and a higher temperature promotes further cell disruption and phenolic compound breakdown. There have also been reports that a significant decrease in polyphenol may result from increased and/or prolonged thermal treatment, such as boiling, cooking, and sun-drying, since most of these compounds are relatively unstable compared to certain heat-stable ones [28].

3.2.7. Tannin Content

According to Table 2, the tannin content of the *mpoto* samples ranged from 1.74 to 2.91%. The sample with the highest tannin content, the *cocoindia* sample, was stored for zero months at 2.91%, while the sample with the lowest tannin content, the *edeofe* sample, was stored for three months at 1.74%. There was a significant difference ($p<0.05$) between the samples. The current study's values are also less than the 3% lethal dose level reported by Rathod and Valvi [42]. Tannins have both medicinal and toxic properties. Higher intakes of tannic acid have been linked to poor protein utilization, liver and kidney toxicity, and carcinogenic effects in humans [7]. Polyphenolic compounds with a bitter taste that speed up wound healing are called tannins. They also have antidiuretic and antidiarrheal properties. It has been documented that tannin can specifically prevent HIV replication [7]. Treating viral diseases could benefit from the use of *mpoto*. The use of cocoyam leaves by local herbalists for the treatment of gastrointestinal disorders may be attributed to their elevated tannin content. Three different varieties of *mpoto* had tannin contents lower than 40.6 mg/100g in raw *Tefairia occidentalis* leaf meal [43]. Tannins have been suggested to possess anti-helminthic and anti-carcinogenic qualities [33]. On the other hand, studies indicate that increased tannic acid consumption has been linked to poor protein utilization as well as toxicity to the kidneys and liver. In contrast to the high levels of tannins found in some common vegetables reviewed in this work as delicacies, the levels in mpoto appeared moderate. As tannins are water-soluble, washing and sun-drying vegetables reduces their tannin content [30].

From the findings of this study, it was observed that as the storage period increased from 0 days through 1, 2, and 3 months, the phytochemical contents of the samples decreased. This could be because of enzyme activity. Phytochemicals are broken down by oxidative enzymes that were not fully inactivated during processing.

Table 1. Phytochemical composition (%) of *achicha* during three months storage[a]

Phytochemical	***Edeofe***				***Cocoindia***				***Anampu***			
	0month	**1 month**	**2 months**	**3 months**	**0month**	**1 month**	**2 months**	**3 months**	**0month**	**1 month**	**2 months**	**3 months**
Alkaloid	$1.49^{c}\pm0.01$	$1.34^{e}\pm0.01$	$1.29^{f}\pm0.01$	$1.24^{g}\pm0.01$	$1.35^{e}\pm0.01$	$1.28^{f}\pm0.02$	$1.23^{g}\pm0.00$	$1.19^{h}\pm0.01$	$1.63^{a}\pm0.01$	$1.54^{b}\pm0.01$	$1.49^{c}\pm0.01$	$1.38^{d}\pm0.03$
Tannin	$0.93^{c}\pm0.01$	$0.77^{e}\pm0.01$	$0.71^{f}\pm0.01$	$0.67^{g}\pm0.02$	$1.08^{b}\pm0.02$	$0.85^{d}\pm0.01$	$0.77^{e}\pm0.01$	$0.71^{f}\pm0.01$	$1.14^{a}\pm0.01$	$0.91^{c}\pm0.01$	$0.84^{d}\pm0.01$	$0.75^{e}\pm0.00$
Saponin	$1.44^{e}\pm0.01$	$1.42^{e}\pm0.01$	$1.39^{f}\pm0.01$	$1.27^{h}\pm0.01$	$1.63^{b}\pm0.01$	$1.58^{c}\pm0.00$	$1.55^{d}\pm0.01$	$1.35^{g}\pm0.01$	$1.71^{a}\pm0.01$	$1.64^{b}\pm0.02$	$1.64^{b}\pm0.02$	$1.43^{e}\pm0.01$
Flavonoid	$0.58^{d}\pm0.00$	$0.57^{d}\pm0.02$	$0.53^{e}\pm0.01$	$0.39^{g}\pm0.01$	$0.67^{b}\pm0.02$	$0.62^{e}\pm0.00$	$0.59^{d}\pm0.01$	$0.34^{h}\pm0.00$	$0.71^{a}\pm0.01$	$0.68^{b}\pm0.00$	$0.63^{c}\pm0.01$	$0.46^{f}\pm0.00$
Polyphenol	$1.43^{c}\pm0.00$	$1.41^{c}\pm0.01$	$1.27^{f}\pm0.02$	$1.27^{f}\pm0.02$	$1.39^{d}\pm0.01$	$1.34^{e}\pm0.02$	$1.33^{e}\pm0.01$	$1.25^{f}\pm0.01$	$1.53^{a}\pm0.00$	$1.49^{b}\pm0.00$	$1.44^{c}\pm0.01$	$1.31^{e}\pm0.01$
Oxalate	$2.75^{b}\pm0.01$	$2.73^{b}\pm0.01$	$2.67^{b}\pm0.02$	$2.56^{c}\pm0.05$	$2.62^{c}\pm0.02$	$2.61^{c}\pm0.02$	$2.41^{e}\pm0.01$	$2.27^{e}\pm0.01$	$3.04^{a}\pm0.03$	$2.93^{ab}\pm0.01$	$2.88^{ab}\pm0.03$	$2.67^{bc}\pm0.05$
Phytate	$1.77^{a}\pm0.01$	$1.74^{a}\pm0.01$	$1.68^{b}\pm0.06$	$1.66^{b}\pm0.02$	$1.56^{c}\pm0.00$	$1.53^{c}\pm0.01$	$1.4^{de}\pm0.01$	$1.40^{e}\pm0.02$	$1.64^{b}\pm0.00$	$1.57^{c}\pm0.03$	$1.53^{cd}\pm0.01$	$1.46^{de}\pm0.01$

[a]Values are means of three independent determinations ±SD. Means in the same row with the same superscript are not significantly different at $p > 0.05$.

Table 2. Phytochemical composition % of *mpoto* during three months storage[a]

Phytochemical	***Edeofe***				***Cocoindia***				***Anampu***			
	0 month	**1 month**	**2 months**	**3 months**	**0 month**	**1 month**	**2 months**	**3 months**	**0 month**	**1 month**	**2 months**	**3 months**
Alkaloid	$1.77^{b}\pm0.01$	$1.74^{c}\pm0.02$	$1.71^{cd}\pm0.01$	$1.62^{ef}\pm0.00$	$1.69^{d}\pm0.01$	$1.64^{e}\pm0.01$	$1.60^{f}\pm0.01$	$1.52^{g}\pm0.02$	$1.85^{a}\pm0.01$	$1.77^{b}\pm0.01$	$1.74^{c}\pm0.02$	$1.72^{c}\pm0.00$
Tannin	$2.47^{d}\pm0.02$	$2.34^{e}\pm0.00$	$1.92^{h}\pm0.00$	$1.74^{i}\pm0.00$	$2.91^{a}\pm0.01$	$2.58^{c}\pm0.03$	$2.18^{g}\pm0.0,$	$2.17^{g}\pm0.01$	$2.67^{b}\pm0.05$	$2.29^{f}\pm0.01$	$2.16^{g}\pm0.01$	$1.91^{h}\pm0.01$
Saponin	$1.86^{b}\pm0.02$	$1.80^{d}\pm0.00$	$1.75^{ef}\pm0.02$	$1.72^{f}\pm0.00$	$1.93^{a}\pm0.04$	$1.85^{b}\pm0.01$	$1.84^{b}\pm0.02$	$1.79^{d}\pm0.01$	$1.84^{b}\pm0.01$	$1.77^{de}\pm0.01$	$1.73^{f}\pm0.01$	$1.67^{g}\pm0.01$
Flavonoid	$0.73^{e}\pm0.01$	$0.68^{g}\pm0.01$	$0.65^{h}\pm0.00$	$0.60^{i}\pm0.00$	$0.87^{a}\pm0.02$	$0.82^{b}\pm0.00$	$0.77^{c}\pm0.01$	$0.74^{d}\pm0.02$	$0.79^{c}\pm0.01$	$0.77^{c}\pm0.01$	$0.71^{g}\pm0.01$	$0.66^{h}\pm0.03$
Polyphenol	$1.64^{c}\pm0.02$	$1.61^{c}\pm0.00$	$1.53^{d}\pm0.01$	$1.48^{e}\pm0.00$	$1.71^{a}\pm0.01$	$1.66^{b}\pm0.01$	$1.63^{b}\pm0.00$	$1.53^{d}\pm0.01$	$1.54^{d}\pm0.01$	$1.53^{d}\pm0.01$	$1.47^{e}\pm0.01$	$1.38^{f}\pm0.03$
Oxalate	$1.81^{a}\pm0.01$	$1.78^{b}\pm0.02$	$1.76^{b}\pm0.01$	$1.66^{d}\pm0.04$	$1.71^{c}\pm0.01$	$1.67^{d}\pm0.02$	$1.65^{d}\pm0.01$	$1.60^{e}\pm0.00$	$1.60^{e}\pm0.00$	$1.53^{f}\pm0.01$	$1.52^{fg}\pm0.00$	$1.49^{g}\pm0.01$
Phytate	$1.91^{a}\pm0.01$	$1.88^{b}\pm0.02$	$1.82^{c}\pm0.00$	$1.75^{d}\pm0.00$	$1.84^{c}\pm0.02$	$1.77^{d}\pm0.02$	$1.75^{d}\pm0.00$	$1.71^{e}\pm0.01$	$1.75^{d}\pm0.02$	$1.71^{e}\pm0.01$	$1.68^{e}\pm0.01$	$1.63^{f}\pm0.01$

[a]Values are means of three independent determinations ±SD. Means in the same row with the same superscript are not significantly different at $p > 0.05$.

4. Conclusion

Studies examining the effects of various food processing techniques, such as cooking, peeling, chopping, washing, and sun-drying, on phytochemical levels in *achicha* and *mpoto* samples showed that these techniques were influenced by the cocoyam varieties used and the length of storage (0–3 months). Nevertheless, there were still detectable levels of health-promoting phytochemicals, and since they were at low concentrations, there was no risk to human health. The remarkable levels of these phytochemicals in processed cocoyam achicha and mpoto suggest that cocoyam corms and leaves could be valuable in food preparation and potentially helpful in managing certain chronic diseases. Cocoyam is safe to consume and can be used as a vegetable. If the length and dosage of administration are not controlled, cocoyam corms and leaves may have chronic effects when used over an extended period. The findings of this study indicate that to provide a positive and secure outlook for the future consumption of achicha and mpoto, research and development programs involving *in vivo* studies of cocoyam corms and leaves are required. It is advised to consume foods such as *achicha* and mpoto, which contain phytochemicals. To determine how extracts from cocoyam leaves and corms can replace the use of harmful synthetic medications, more research is needed. Newer insights from ongoing research will undoubtedly usher in a new era of pharmaceutical agents derived from *cocoyam* for the treatment of numerous infectious and degenerative diseases.

Conflict of Interest

The authors declare that they have no competing financial interests or personal relationships that could have influenced the work reported in this paper.

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