Effect of Fermentation on Nutrient and Antinutrient Contents of Cocoyam Corm

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Abstract: *Objective*: Cocoyam corms were fermented with the aim of enhancing and reducing its nutrient and antinutrient contents respectively.

Methods: Cocoyam corm was fermentated naturally by submerged fermentation method in a sterile medium (distilled water) for four days. Microbial examination of the fermenting corms was carried out at 24hours interval for four days.

Results: Twenty bacterial strains were isolated within the fermentation periods. They include the general: *Micrococcus* species*, Lactobacillus plantarum, L. fermentum, Enterobacter, Escherichia coli* and *Staphylococcus aureus*. The total bacteria count increased from 5.70 log cfu/ml to 8.97 log cfu/g while fungal count increased from 3.33 log cfu/g to 4.84 log cfu/g. Temperature and the total titratable acidities increased from 27^{o}C to 35^{o}C and 1.13% to 3.72% respectively while the pH values decreased from 5.68 to 3.75. The result of the proximate analysis showed that the fermented sample had higher protein (12.00%), ash (2.84%) and fat (4.84%) contents than the unfermented sample which contained 7.30%, 2.4% and 4.55% respectively. However, moisture, fibre and carbohydrate contents decreased from 9.70%, 3.00% and 73.04% in unfermented sample to 8.94%, 2.78% and 67.60% in fermented sample respectively. All the antinutrient contents decreased at the end of the fermentation [phytate (1.32-0.38) g/100DM, oxalate (0.72-0.21) g/100DM, tannin (0.18-0.07) g/100DM, saponin (0.45-0.22) g/100DM, hydrocyanide (22.27-10.22)g/kg of the fermented sample than the unfermented one.

Conclusion: If properly fermented cocoyam corm could be a potential substitute or supplement for fermented tubers for preparation of food for infants and adults.

Keywords: Cocoyam, fermentation, nutrient, antinutrient, phytochemicals.

INTRODUCTION

Natural fermentation is one of the oldest means of preservation. It involves allowing the substrate to undergo fermentation at room temperature for some days. Subsequently the fermenting organisms are usually from the environment, substrates or equipment used during the fermentation process [1]. Root and tuber crops have been reported to show great promise as novel and cheaper alternative energy to cereals such as maize, sorghum and millets in developing countries. Their stems contain less lignin with high protein potential while their aerial parts have considerable potential as ruminant feed supplement [2]. However, an attempt at fulfilling the energy requirement of human and animal through the use of root and tubers, if well processed, could probably reduce over dependence on cereals and grains [3, 4]. Cocoyam contributes significant portion of the carbohydrate content of the diet in many regions in developing countries. Although, they are less important than other tropical root crops such as yam, cassava and sweet potato, they form major staple in some part of the tropics [5, 6]. Cocoyam is a well-known food plant which has a long history of cultivation. Cocoyams are found as an important crop only in warm, humid forest areas because of their need for high annual rainfall and a long wet season. They thrive well on fairly drained soils and are not usually affected by occasional flooding. They can also be intercropped with other crops and the maturity period falls within 7-10 months.

Cocoyam corms are an important source of starch which could be processed in several ways. They may also be cut up and boiled in curries or fried to make crispsy chips. They can also be boiled and pounded and eaten with soup, although it is not considered as prestigious as pounded yam. It can also be made into snacks, porridge or pottage, chips and flour, as well as alcoholic drinks [7, 8]. Cocoyam is a potential good base for food preparation for infants because of the high digestibility of its starch, reasonable contents of calcium and phosphorus (for bone building), vitamins A and B-complex. The leaf stocks can also be eaten. It had been reported that cocoyam leaves could be cooked and eaten like spinach [9, 10]. Cocoyam has nutritional advantage over root crops and other tuber crops because it contains more crude protein than any other tubers and its starch is highly digestible because it contains smaller the starch granules. They also contain reasonable contents of calcium, phosphorus, vitamin A and B vitamins. Besides, the sulphur amino

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acid and price per tonne make it a better choice than cereals in fish feed production [11, 12]. All these benefits are not tapped due to low production and under-utilization [13].

However, cocoyam has been found to contain antinutrient contents which effect could be minimized by various processing techniques to make cocoyam an excellent source of carbohydrate, vitamins and minerals [14, 15]. Their consumption has been affected by the presence of acridity factors which cause scratchiness and burning sensation in the throat during ingestion [16]. The aim of this study therefore was to study the effect of fermentation on nutrient and antinutrient contents of composition cocoyam corm.

MATERIALS AND METHODS

Source and Preparation of Wild Cocoyam Corm

The cocoyam corm (*Colocasia esculenta*) used for this study was purchased from Ijare market in Ondo State, Nigeria. The corms were peeled and washed thoroughly with clean water. 500 g of the corms were sliced to about 1cm, poured into a sterilized plastic bucket containing 2 litres of sterile water (121^{o}C for 15 minutes) and allowed to ferment at room temperature for 120 hours. The water was drained after the fermentation period and the sliced corms were oven dried at 69^{o}C to constant moisture content. The fermented cocoyam corms were then sterilized using 2% metabisulphite, dried in a drying cabinet and stored in 70% ethanol sterilized air tight plastic container and kept at refrigerator temperature.

Microbial Analyses

The total viable counts of the samples were analyzed daily by the method of [17]. Serial dilutions were done in sterile distilled water while plating of bacteria and fungi was done on plate count agar (Oxoid) and Sabouraud dextrose agar respectively. The mean of replicate plating was calculated and the total number expressed colony forming units per gram (cfu/g). Pure cultures of bacteria and fungi were stored on nutrient agar and potato dextrose agar slants respectively in a refrigerator (at 4^{o}C). The isolates were characterized by cultural, morphological and biochemical tests by Olutiola *et al.* [17] and Onions *et al.* [18].

Physiochemical Parameters

Determination of pH, Total Titratable Acidity (TTA) during fermentation pH and TTA were determined using standard methods of AOAC [19]

Proximate Analysis of Fermented and Unfermented Pigeon Pea

The chemical proximate composition in terms of crude protein, crude fibre, lipid content and carbohydrate was carried out according to standard methods of AOAC [19].

Anti-Nutrient Determination

The raw and fermented cocoyam corms were analysed for the presence of saponins [20], cyanide [21], trypsin inhibitor [22], phytate [23], oxalate [24] and tannin [25].

RESULTS AND DISCUSSION

Bacteria isolated during the fermentation of cocoyam include Lactobacillus plantarum, Lactobacillus fermentum, Micrococcus, Enterobacter, *Escherichia coli*, Staphylococcus aureus while the fungi include

Table 1: Occurrence of Microorganisms from the Fermenting Cocoyam Corms

Isolates	Time (Hours)				
	0	24	48	72	96
Lactobacillus plantarum	+	+	+	+	+
Lactobacillus fermentum	-	+	+	+	+
Micrococcus luteus	+	-	-	-	-
Enterobacter	+	+	-	-	-
Escherichia coli	+	-	-	-	-
Staphylococcus aureus	+	-	-	-	-
Aspergillus niger	+	+	-	-	-
Rhizopus stolonifer	+	+	-	-	-
Saccharomyces cerevisiae	-	-	+	+	+

+ = Present.
- = Absent.

Table 2: Total Bacteria and Fungi Counts from the Fermenting Cocoyam Corms

No of hours	Total bacteria counts (logcfu/g)	Total fungi count (logcfu/g)
0	5.70 ±0.2	3.33±0.2
24	6.09 ±0.4	3.67±0.2
48	7.19 ±0.2	4.13±0.6
72	8.50 ±0.2	4.40±0.3
96	8.97±0.2	4.84±0.4

± = S.D.

Aspergillus niger, Rhizopus stolonifer and Saccharomyces cerevisiae. Table **1** shows the occurrence of microorganisms from the fermenting cocoyam corms. Lactobacillus plantarum and Lactobacillus fermentum were the most frequently occurred bacteria while Saccharomyces cerevisiae was isolated from 72 hours of fermentation till the end of the fermentation period. Micrococcus, E. coli and S. aureus were isolated in day 0 while Enterobacter, A. niger and R. stolonifer were found in days 1 and 2 of the fermentation period (Table **1**). However, the presence of these pathogenic microorganisms could be controlled, if present in food, either by sterilization or incorporation of probiotic microorganisms. According to Donohue and Salminen [26], interest has been focused on health promotion and disease prevention by the incorporation of probiotic bacteria into foods to counteract harmful bacteria in the intestinal tract. Some of the microorganisms isolated during this study have been implicated in the fermentation of many fermented foods [27, 28]. The sources of the organisms could either be from cocoyam corm, water used for processing or the environment [29]. Lactobacillus plantarum L. fermentum and S. cerevisiae were the predominant microorganisms isolated from the fermentation of cocoyam corms [30]. This was similar to Lyumugabe [31] while fermenting. Holzapfel [32] reported initial predominance of lactic acid bacteria in some African alcoholic beverages in which yeast later play the dominant role. Due to their higher growth rate, bacteria typically dominate the early stages of the fermentation process. (Munyaja et al. [33] also reported symbiotic relation between lactic acid bacteria and yeasts in which the former was responsible for an acid environment which was favorable for the proliferation of yeasts while the latter produce vitamin and increase other factors such as amino-acids for the growth of lactic acid bacteria [34]. Microbial counts were observed to increase with ranges of 5.7 and 8.9 log cfu/g, and 3.33 and 4.84 log cfu/g obtained from bacterial and fungal counts respectively (Table **2**). The increase in microbial counts could be attributed to the breakdown of organic constituents of the corms to simpler ones that could easily be metabolised by the fermenting microorganisms for their growth [34]. Higher bacterial contents had been reported in many fermented food than fungal counts [35]. This could be due to the shorter generation period of the former. Temperature of the fermenting cocoyam corms increased from 27 to 35^{o}C could be as a result of the heat generated during metabolism of the sample by the fermenting organisms. It was observed that the pH decreased from 5.68 to 3.75 while the total titratable acidity increased from 1.13% to 3.75% (Table **3**). The results of TTA and pH were in agreement with Wakil and Kazeem [36] while working on fermented cereal-legume blends. The increases in TTA and subsequent decrease in pH had been reported to be associated with fermentation dominated by lactic acid bacteria and yeasts might be as result of due to the production of

Table 3: Temperature, pH and Total Titratable of the Fermenting Cocoyam Corm

Hours	Temperature (^{O}C)	TTA(%)	pH
0	27.0±0.1	1.13±0.4	5.68±0.6
24	29.0±0.1	1.30±0.2	4.90±0.8
48	30.0±0.2	2.78±0.3	4.40±0.4
72	33.0±0.2	3.31±0.2	3.90±0.5
96	35.0±0.2	3.72±0.4	3.75±0.6

± = S.D.

Table 4: Proximate Analysis of Fermented and Unfermented Cocoyam (Dry Weight)

Nutrient	Unfermented sample (%)	Fermented sample (%)
Moisture content	9.70±0.6	8.94±0.2
Ash	2.40±0.02	2.84±0.4
Protein	7.30±0.6	12.00±0.6
Fat	4.55±0.2	4.84±0.3
Crude fibre	3.00±0.2	2.78±0.2
Carbohydrate	73.04±3.2	67.60±2.5

± = S.D.

organic acids in the substrate [37; 38]. This will invariably reduce the proliferation of pathogenic microorganisms and subsequent incidence of diseases [39]. Table **4** shows the results of the proximate composition of the fermented and unfermented cocoyam corms. Parameters which increased after fermentation include protein content (7.3 - 12)%, ash content (2.40 - 2.84)% and fat content (4.55 - 4.84)% while reduction were observed in moisture content (9.70 – 8.94)%, crude fibre (3.00 -2.78)% and carbohydrate contents (73.04 – 67.60)% (Table **5**). Increases in the protein and fat contents observed after fermentation which conforms with Oboh and Elusiyan [40] might result from the increase in the cell number of the fermenting microorganisms or their ability to synthesise them. Protein and fat were parts of the major constituents of microbial cells. Oboh and Akindahunsi [41] suggested that it was possible for the fermenting organisms to be involved in the synthesis of fats. However the reduction in fibre and carbohydrate contents could be due to the fact that they were utilised by the microorganisms for their cell growth [40]. The increase in ash content of fermented cocoyam corm was in agreement with Oyarekua [42]. However, Onoja and Obizoba [43] observed reduction in ash content while fermenting pigeon pea which they attributed to leaching into the processing water or being metabolised by the microbial contents of the fermenting substrate.

All the antinutrient contents decreased after fermentation with the highest percentage decrease in phytic acid (71.2%) followed by oxalate content (70.8%) while tannin, hydrocyanide and saponin contents reduced by 61.1%, 54.0% and 51.2% respectively (Table **5**). Significant reductions in antinutrient contents of cocoyam corms after fermentation compare well with other fermented foods [43, 44]. The reduced values of these antinutrient contents are nutritionally advantageous. The decrease in phytate levels was attributed to the activities of phytase during fermentation. Phytase dephosphorylates phytate leading to the formation of inositol and phosphoric acid which subsequently releases phosphorus thus increasing its bioavailability [45]. Besides, Fardiaz and Markakis [46] reported that decrease in phytic acid may be due to leaching of this compound into the soaking water.

Decreases in cyanide with increase in fermentation time have been associated with hydrolytic activities of enzymes from the fermenting microorganisms [47]. Endogenous hydrolytic enzymes that occur in cyanophoric tissues may also have contributed to the hydrolysis of the cyanogens into non toxic sugar moiety and cyanohydrin. Cyanide has been reported to be very toxic at low concentration to animals [48]. Cyanide can cause dysfunction of the central nervous system, respiratory failure and cardiac arrest [49, 50]. Thermal

Table 5: Anti-Nutrient Content of Fermented and Unfermented Cocoyam Corms

Anti nutrient	Unfermented sample	Fermented sample	% decrease
Tannin (g/100DM)	0.18±0.02	0.07±0.01	61.1
Oxalate (g/100DM)	0.72±0.02	0.21±0.02	70.8
Phytate (g/100DM)	1.32±0.01	0.38±0.02	71.2
Saponin (g/100DM)	0.45±0.01	0.22±0.01	51.2
Hydrocyanide (mg/kg)	22.27±0.21	10.24±0.71	54

± = S.D.

Table 6: Sensory Evaluation of the Fermenting Cocoyam Corms

Hours	Colour	Odour	Slimness
0	Creamy	Not offensive	No sliminess
24	Creamy	Slightly offensive	No sliminess
48	Creamy	Offensive	Little sliminess
72	Brownish	Offensive	Little sliminess
96	Brownish	More offensive	More slimy

treatment prior to fermentation had been reported to enhance reduction of cyanide contents in foods [2, 16]. However, the cyanide levels which were present after fermenting the corms were far below the detrimental level of 30 mg/kg [51]. The product could therefore be considered safe with regard to cyanide poisoning. The observed decrease in tannin with increase in fermentation time agrees closely with the report of *Oboh et al.* [52] while fermenting cassava for flour and *gari* production. The decreases were attributed to the hydrolysis of polyphenolic compounds or tannin complexes during fermentation. Obizoba and Atii [53] reported that tannin-protein, tannic acid-starch and tannin-iron complexes are broken down during fermentation to release free nutrients. Since tannins are known to reduce the availability of proteins, carbohydrates and minerals through the formation of indigestible complexes, breakdown of such complexes will invariably improve the availability of the nutrients. Nnam [54] reported increased availability of proteins and minerals in children fed diets that had reduced tannin level through fermentation.

The anti-nutritional effects of saponins include increased permeability of small intestinal mucosa cells thereby inhibiting nutrient transport [55]. Endogenous saponins reduces protein digestibility of soybean by chymotrypsin probably by the formation of sparingly digestible saponin-protein complexes [56, 57]. Oxalates affects calcium and magnesium metabolism and react with proteins to form complexes which have an inhibitory effect in peptic digestion [48].

CONCLUSION

From the results from this study show that fermentation has tremendously improved the protein, fat and ash contents of cocoyam corms. Besides, significant reductions were also observed in all the antinutrient contents after fermentation. Further studies on fermented cocoyam corms should include the use of starter cultures so as to find out the main microorganisms responsible for the fermentation.

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