Effect of processing conditions on chemical composition and consumer acceptability of cocoyam (colocasia esculentus) elubo

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Abstract

Introduction. The effect of two processing conditions on chemical and consumer acceptability of cocoyam (taro) elubo was investigated.

Materials and methods: Fresh taro tubers were processed into elubo using traditional method of four treatments ($P_{50}S_{12;}$ $P_{50}S_{24;}$ $P_{60}S_{12}$ and $P_{60}S_{24}$) from parboiling at 50^0C for 3h and at 60^0C for 1h; steeping in water for 12h and 24h. Standard methods were used to determine the proximate and mineral composition of the elubo samples. A stiff gel (amala) was prepared from the elubo samples to evaluate the sensory quality and consumer acceptability.

Results and discussion: The proximate composition of the taro elubo samples revealed that the processing treatments had no significant ($p<0.05$) effect on the crude fibre (3.80 to 3.83%), carbohydrate (77.50 to 78.80%), and calories (345.32 to 349.47K), while, significant ($p<0.05$) effects were observed on the moisture (8.39 to 9.30%), ash (1.56 to 2.98%) and protein (5.08 to 6.26%) contents. Parboiling at 50^0C resulted in lower moisture content, though all the values are still within the acceptable level for storage of food flour. The ash content of the taro elubo was significantly ($p<0.05$) influenced by steeping at 12h with elubo sample obtained from $P_{60}S_{12}$ treatment having the highest value. Stepping at 12h also favoured the protein content, the $P_{50}S_{12}$ recorded the highest value. The usual lost of minerals through heat treatment (parboiling) and leaching (stepping) was observed as the fresh taro had significantly ($p<0.05$) high mineral composition. Elubo sample obtained from $P_{50}S_{12}$ and $P_{60}S_{12}$ treatments the highest value for calcium (30.87mg/100g) and potassium (47.00mg/g) respectively. Increase in steeping time caused a significant ($p<0.05$) reduction in the values obtained for calcium, potassium and sodium. There was no significant ($p<0.05$) effect on the iron and manganese contents of the elubo samples. The sensory qualities of the amala samples showed that parboiling of taro at 50^oC resulted in amala having no significant ($p<0.0$) difference in colour, taste, aroma, consistency and general acceptability with yam amala (the reference sample). This indicates that low heat treatment is required for processing of taro corms.

Conclusions. The study showed that the parboiling at 50^oC and stepping at 12h favoured the chemical and sensory qualities and consumer acceptability of taro elubo than parboiling at 60^oC and stepping at 24h.

Introduction

Cocoyam commonly called taro is an underutilized crop mainly grown for its edible corms. Taro (*Colocasia esculenta*) and Tannia (*Xanthosoma sagittifolium*) are the two most important genera of the family *Aracea* [40, 14, 2]. They constitute one of the six most important root and tuber crops worldwide [13]. Although, they are less important than other tropical root crops such as yam, cassava and sweet potato, they are still a major staple in some parts of the tropics and sub-tropics [38]. Taro is produced in abundance in Nigeria, but less valued as it is regarded as staple food for rural dwellers, the poor and the less privileged in society [20, 34]. The nutritional and chemical composition as reported by FAO [15] shows that cocoyam if fully exploited would enhance the food security of people living in the tropics [14].

Corms of taro have generally been reported to contain digestible starch which is an important factor when selecting a starchy food that will not be cumbersome on the digestive system [19] protein of good quality, ascorbic acid, thiamin, riboflavin, niacin and high scores of amino acids [32]. Report shows that 70 – 80% starch content is with small size granules [37, 8, 34], which result in high digestibility. According to [22] starch derived from taro corm is unique because of its very small granular size ranging from 1–5 μ, significantly smaller than that of corn and wheat. The protein and amino acids content are also higher than other tropical root crops [24, 7]. It is also rich in dietary fibre, thiamine, calcium, niacin, manganese, magnesium, copper and riboflavin. Consuming nutrients-packed food like taro is vital for maintaining a healthy immune system, which helps our body to make use of protein, carbohydrates and other nutrients in the food [36].

Processing greatly increase the utilization of root crops and reduces annual post-harvest loss of about 30% [23]. Cocoyam flour (*elubo*) like yam *elubo* is a major form in which the tuber could be preserved and consumed during the periods preceding yam harvest and this underscores its importance as a possible substitute for yam in Nigeria [1,18, 4]. The processing method however affects final product quality [29, 30, 32].

In the traditional production of *elubo*, the major processing units of critical control include; parboiling, steeping, and drying [31, 11, 30]. Parboiling and steeping improve the digestibility, promote palatability, improve keeping quality, reduces anti-nutritional factors and have effect on the major nutrients, including proteins, carbohydrates, minerals and vitamins [29, 28, 30, 32], hence appropriate processing conditions are required to ascertain quality of the final product. The study was designed to determine the effect of parboiling and steeping conditions on for proximate, minerals and acceptability of taro elubo.

Materials and methods

The cocoyam corms were obtained from the local food market in Osogbo, Osun State, Nigeria.

Production of cocoyam *elubo*

The method reported by [29] was adopted for production of the cocoyam *elubo*. Clean cocoyam corms were sorted from infected tubers. The selected tubers were peeled and reduced into even chips (150±3g). The chips were divided into for parboiling at 50^0C for 3h and at 60^0C for 1h, steeped in the warm water for 12h and 24h resulting into four treatments. The parboiled chips were later sun-dried till a constant weight was obtained.

The dried chips were milled into flour (*elubo)* using attrition mill and sieved with 0.25um sieve. The *elubo* samples were packaged in high density polyethylene bags (10mm thickness) for further analysis.

Proximate Analysis

Proximate composition of the taro *elubo* samples were determined using the method described by AOAC [9]. Moisture, ash, crude fat, protein and crude fibre were determined, while carbohydrate content was determined using difference method.

Mineral Analysis

The mineral content of the *elubo* was determined using the method described by [27]. *Elubo* sample of 0.5g was weighed into a clean ceramic crucible. A blank was prepared with empty crucible. The crucible was placed in a muffle furnace at 50^{0}C for 4 h. The sample was allowed to cool down in the oven after which it was removed carefully. The ashed sample was poured into already labeled 50ml centrifuge tube. The crucible was rinsed with 5ml of distilled water into the centrifuge tube. The crucible was rinsed again with 5ml of aqua regia. This was repeated to make a total volume of 20ml. The sample was mixed properly and centrifuged (ICE Centra GP8) for 10 minutes. The supernatant was decanted into clean vials for mineral determination. The absorbance was read on atomic absorption spectrophotometer (Buck Scientific Model 200A) at different wavelength for each mineral element (copper -324.8nm, zinc -213.9nm, calcium -422.7nm, iron -248.3nm, magnesium-285.2nm, manganese -279.5nm, sodium -589nm and potassium -766.5nm).

Preparation of *amala*

The procedure described by [10] was adopted for the preparation of taro *amala.* About 50g taro *amala* was added to 200ml boiled water. The paste was stirred manually with a wooden spoon over a low flame until a smooth consistency was obtained.

Sensory evaluation and consumer acceptability test

The sensory quality [1] and consumer acceptability of *taro amala* was evaluated using 50 panelists that were familiar with *yam amala.* A nine point hedonic scale as described by [21, 19] was adopted. The scale ranged from like extremely (9) to dislike extremely (1). Each of the samples was rated for appearance, aroma, taste, texture, mouth feel and overall acceptability

Statistical analysis

Data were subjected to multiple analyses of variance (MANOVA) at 5% significance level, and mean of samples separated by Duncan multiple range test (DMRT) using statistical package for social sciences (SPSS) version 20.0.

Results and Discussion

Proximate composition of taro *elubo*

The result of proximate composition of fresh taro and taro *elubo* is presented in Table 1. The two varied processing units (parboiling and steeping) were observed to have significant ($p<0.05$) effect on the taro *elubo* samples. Fresh taro corms constitute majorly of moisture with other macronutrients in low concentration [34]. The apparent increase in protein, fat, crude fibre and carbohydrate contents observed in taro *elubo* samples could be as a result of the removal of moisture and processing conditions which tend to increase the concentration of nutrients [26].

The moisture content ranging from 8.39 to 9.30% was significantly ($p<0.05$) affected by the processing conditions. *Elubo* from $P_{50}S_{24}$ treatment had the lowest moisture content, while the highest value was observed in *elubo* from $P_{60}S_{12}$ treatment. The results revealed that parboiling at 50°C and steeping for 24h resulted into lower moisture content compared to parboiling at 60°C and steeping for 24h. This could be as a result of more dissociation of the starch granules, easing heat transfer and surface evaporation of moisture. Moisture content of food or processed products give an indication of its anticipated shelf life. High moisture content enhances microbial contamination and reduces food quality and stability [5], therefore the lower the moisture content of a sample, the more its storability. The values are lower than the values (9.43 – 10.47%) reported for cocoyam flour by [31], however the values fall within the acceptable limit of not more than 10% for long term storage of flour [33, 12].

The fresh corm had the significantly ($p<0.05$) highest ash content, which indicates that taro in their fresh state is rich in minerals [7, 14]. The effect of parboiling and steeping conditions is thus significant ($p<0.05$) on the ash contents of the *elubo* samples. Parboiling and steeping conditions have been reported to reduce ash content of processed food products [6, 11]. The ash contents of the taro *elubo* are higher than the value reported for yam *elubo* (1.84%) by [25] and [11]. While, the range of 1.56 to 2.98% reported by [39] for cocoyam flour is similar to the values obtained from the study. The result indicates that the taro *elubo* could be a good source of essential minerals and trace elements.

The protein content of root and tuber crops is generally low. Processing of taro into *elubo* influenced the protein content due to concentration of the nutrient upon drying. The highest value (6.45%) was obtained from *elubo* from $P_{50}S_{24}$, treatment, while *elubo* from $P_{60}S_{12}$ had the lowest value (5.06%). The variation in protein content consequently was due to the effect of the processing conditions. Heat application denatures proteins [26, 19, 24]. At higher parboiling temperature (60°C), lower protein content was obtained, which may be as a result of heat denaturation of protein. Parboiling has been found to decrease protein content due to leaching of nitrogenous substances during steeping and rupturing of molecules during steaming [35] and this might be the reason for the observed effect. Also decrease in protein content probably occurred as a result of Maillard reaction, which occurs between carbohydrates and protein [2, 41]. Browning of *elubo* is responsible for the characteristic colour of the cooked paste (amala). The result is similar with the values reported by [29] and greater than the values reported by [3, 1, 28] for yam *elubo*. This explains that taro has higher protein content (thermo-stable) than yam.

There was no significant difference ($p<0.05$) between the fat contents of the taro *elubo* samples. Fat content in flour explains storability of the flour due to various chemical reactions associated with lipid oxidation [38]. Fat also serve as energy store in the body when is broken down to release glycerol thereafter converted into glucose (energy) by the liver. It has been reported that 1g of fat provides 37Kcal of energy [16]. The low fat content of taro *elubo* may make it suitable for diabetics and people suffering from cardiovascular diseases.

The crude fibre content is similar to the ash content. The effect of the processing conditions were not significant ($p<0.05$) on the fibre content. These values compared well with values reported for cocoyam flour by [28, 29, 18]. Crude fibre represents the content of the non-digestible components of food, such as lignin, cellulose and hemicelluloses. These are essential in human nutrition, since they enhance the transit time through the bowels, facilitates bowels movement thus reducing the risk of colon cancer. The results indicate that taro *elubo* is rich in insoluble dietary fibre. This may be relevant in African's food and nutritional security. The high carbohydrate content of fresh taro was reflected on the values obtained from the *elubo* samples (77.50 to 78.80%). There was no significant ($p<0.05$) effect of the processing conditions on the carbohydrate content. However, the values are slightly higher than values obtained for yam flour from the study reported by [2] and cocoyam flour by [29]. Carbohydrate supplies energy to the body, contributes to fat metabolism, spares proteins as an energy source, act as a mild natural laxative for human beings and generally add to the bulk of the diet [16].

All the calorie contents of all the taro *elubo* samples are higher and significantly ($p<0.05$) different from the value of the fresh corm. The *elubo* from $P_{50}S_{24}$ treatment had the highest calorific value. The result revealed that taro *elubo* though is a good source of carbohydrate, can be consumed in large amount without a substantial increase in the glycemic load in the body.

Mineral composition of fresh taro and taro *elubo*

The ranges of the mineral composition of taro *elubo* were: calcium (23.28 to 53.64 mg/100g), potassium (21.45 to 79.53 mg/100g), sodium (15.33 to 65.22 mg/100g), magnesium (8.38 to 26.2 mg/100g), phosphorus (0.43 to 1.31 mg/100g), iron (0.22 to 1.53 mg/100g), zinc (0.10 to1.32mg/kg), and manganese (1.10 to 3.48 mg/100g) as shown in Table 2. The nutritional potential, health and food security benefits of taro are justified with the rich essential mineral content [41].The variation in the mineral composition might have been influenced by the processing conditions as higher values were obtained for the fresh taro corm. Minerals are usually lost through heat treatment and leaching during parboiling and stepping, most especially with potassium, calcium and magnesium [41, 18]. The processing methods had significant effect on potassium, calcium, sodium, magnesium and phosphorus, while no effect was obtained for iron and manganese contents. According to Hassan *et al.*, [17] during processing the nutritive value and antinutritional components of roots and tubers may be adversely affected. Calcium is important in the body as it helps to build and maintain bones and teeth [41].

Sodium and potassium are water soluble and are sensitive to high heat processing. Increase in steeping time caused a significant reduction in the values obtained for potassium and sodium. Also, *elubo* samples obtained from steeping of taro for 12h showed better values for potassium and sodium. *Elubo* sample from $P_{60}S_{12}$ treatment had the highest sodium content while *elubo* sample from $P_{50}S_{24}$ treatment had the lowest value. Potassium and sodium are important in the diet as they help to regulate acid-base equilibrium and osmotic pressure of body fluid.

The values obtained for magnesium, phosphorus, iron, zinc and manganese are lower than the values reported by Hassan *et al*. [17].

Table 1

Proximate composition of Fresh taro and taro *elubo*

Samples	Moisture (%)	Ash (%)	Crude Protein (%)	Fat (%)	Crude fibre (%)	Carbohydrate (%)	Calorie (KJ)
Fresh Taro	$48.93^{a}\pm0.42$	$5.17^{a}\pm0.27$	$2.08^{c}\pm0.22$	$0.63^{a}\pm0.01$	$2.30^{b}\pm0.17$	$40.90^{b}\pm0.53$	$177.54^{b}\pm1.34$
$P_{50}S_{12}$	$8.82^{b}\pm0.74$	$1.98^{bc}\pm0.14$	$6.26^{b}\pm0.44$	$1.34^{a}\pm0.32$	$3.83^{a}\pm0.00$	$77.77^{a}\pm1.20$	$348.78^{a}\pm3.72$
$P_{50}S_{24}$	$7.95^{b}\pm0.90$	$1.70^{c}\pm0.07$	$6.45^{a}\pm0.51$	$1.28^{a}\pm0.77$	$3.81^{a}\pm0.00$	$78.81^{a}\pm1.24$	$352.52^{a}\pm0.06$
$P_{60}S_{12}$	$9.30^{b}\pm0.37$	$2.20^{b}\pm0.07$	$5.86^{b}\pm0.80$	$1.32^{a}\pm0.47$	$3.82^{a}\pm0.04$	$77.50^{a}\pm1.52$	$345.32^{a}\pm1.33$
$P_{60}S_{24}$	$8.39^{b}\pm1.02$	$1.82^{bc}\pm0.58$	$5.08^{c}\pm0.77$	$1.23^{a}\pm0.64$	$3.80^{a}\pm0.00$	$79.68^{a}\pm2.29$	$349.47^{a}\pm0.31$

Mean values with different superscripts within the same column are significantly different at $p< 0.05$

$P_{50}S_{12}$: parboiled at 50°C, steeped for 12h
$P_{50}S_{24}$: parboiled at 50°C, steeped for 24h
$P_{60}S_{12}$: parboiled at 60°C, steeped for 12h
$P_{60}S_{24}$: parboiled at 60°C, steeped for 24h

Table 2

Minerals composition of fresh taro and taro *elubo*

Samples	Calcium (mg/100g)	Potassium (mg/100g)	Sodium (mg/100g)	Magnesium (mg/100g)	Phosphorous (mg/100g)	Iron (mg/100g)	Zinc (mg/kg)	Manganese (mg/100g)
Fresh	53.64^{a} ±1.03	79.53^{a} ±0.96	65.22^{a} ±0.40	26.2^{a} ±0.53	2.03^{a} ±0.10	1.53^{a} ±0.05	1.32^{a} ±0.03	3.48^{a} ±0.78
$P_{50}S_{12}$	30.87^{b} ±0.72	$26.33^{c\backslash}$ ±1.14	23.15^{c} ±1.15	8.67^{bc} ±0.16	0.88^{c} ±0.18	0.22^{b} ±0.04	0.15^{b} ±0.01	1.15^{b} ±0.18
$P_{50}S_{24}$	25.30^{cd} ±0.11	21.45^{c} ±1.76	$15.33^{d\backslash}$ ±1.15	8.38^{c} ±0.07	0.92^{b} ±0.48	0.42^{b} ±0.29	0.15^{b} ±0.01	1.15^{b} ±0.00
$P_{60}S_{12}$	26.31^{bc} ±1.16	47.00^{b} ±2.86	31.63^{b} ±1.38	8.72^{b} ±0.26	0.43^{d} ± 0.25	0.44^{b} ±0.07	0.10^{c} ±0.03	1.10^{b} ±0.02
$P_{60}S_{24}$	$23.2\ 8^{d}$ ±0.10	27.79^{c} ±1.58	18.59^{cd} ±1.38	8.56^{bc} ±0.12	0.57^{cd} ±0.27	0.51^{b} ±0.02	0.12^{c} ±0.00	1.23^{b} ±0.13

Mean values with different superscripts within the same column are significantly different at $p< 0.05$

$P_{50}S_{12}$: parboiled at 50°C, steeped for 12h
$P_{50}S_{24}$: parboiled at 50°C, steeped for 24h
$P_{60}S_{12}$: parboiled at 60°C, steeped for 12h
$P_{60}S_{24}$: parboiled at 60°C, steeped for 24h

Sensory properties of taro *amala*

The mean sensory scores of *amala* produced from the taro *elubo* samples varied significantly ($p<0.05$) as shown in Table 3. The *amala* prepared from sample $P_{50}S_{24}$ treatment had the highest mean score of 7.70 for colour and was more preferred than the reference sample (*amala* from yam *elubo*). The aroma values ranged from 7.55 to 6.20 with *amala* prepared from *elubo* of $P_{50}S_{12}$ treatment having the highest score and *amala* from $P_{60}S_{24}$ treatment having the least score. The reference recorded 7.05 for taste which were lower than some scores obtained for the taro *amala* samples. This indicates that on the average level, the taro *amala* samples had better scores than the yam *amala*. Parboiling of taro at 50°C influenced the consistency quality and mouth feel qualities. Consistency of *amala* explains the firmness and viscosity quality. This is one of the major acceptable characteristics of the stiff dough [3, 1, 23]. In generally, yam *amala* was most accepted than the taro *amala* samples. However, the *amala* obtained from taro *elubo* parboiled at 50°C were not significantly different from the reference. This indicates that low heat treatment is required for processing of taro corms.

Table 3

Sensory Quality and Consumer Acceptability scores of taro *amala*

Samples	Colour	Taste	Aroma	Mouth feel	Consistency	General Acceptability
Reference	$7.65^{a}\pm1.18$	$6.89^{b}\pm1.73$	$7.05^{cd}\pm1.42$	$7.40^{a}\pm1.79$	$7.0^{b}\pm1.45$	$7.71^{a}\pm1.14$
$P_{50}S_{12}$	$7.67^{a}\pm1.40$	$6.97^{ab}\pm1.69$	$7.55^{a}\pm1.74$	$7.05^{b}\pm1.62$	$7.08^{ab}\pm1.84$	$7.67^{a}\pm1.56$
$P_{50}S_{24}$	$7.70^{a}\pm1.56$	$7.00^{a}\pm0.73$	$7.15^{c}\pm0.99$	$7.15^{ab}\pm1.04$	$7.15^{a}\pm0.93$	$7.60^{a}\pm0.73$
$P_{60}S_{12}$	$7.15^{b}\pm1.46$	$6.65^{c}\pm1.76$	$7.30^{b}\pm1.87$	$6.65^{c}\pm1.47$	$6.13^{e}\pm1.80$	$6.85^{b}\pm1.69$
$P_{60}S_{24}$	$6.25^{c}\pm1.21$	$6.05^{cd}\pm1.54$	$6.20^{f}\pm1.47$	$6.95^{bc}\pm1.40$	$6.38^{d}\pm1.46$	$6.70^{d}\pm1.38$

Mean values with different superscripts within the same column are significantly different at $p< 0.05$
Reference: Amala prepared from yam *elubo*
$P_{50}S_{12}$: Amala prepared from taro *elubo* parboiled at 50°C and steeped for 12h
$P_{50}S_{24}$: Amala prepared from taro *elubo* parboiled at 50°C and steeped for 24h
$P_{60}S_{12}$: Amala prepared from taro *elubo* parboiled at 60°C and steeped for 12h
$P_{60}S_{24}$: Amala prepared from taro *elubo* parboiled at 60°C and steeped for 24h

Conclusion

The study has shown that the chemical qualities of taro *elubo* are significantly influenced by the processing conditions. Parboiling at 50°C and stepping at 12h favoured the chemical qualities than parboiling at 60°C and stepping at 24h. *Amala* from elubo produced from parboiling at 50°C and stepping at 12h was also found to have similar sensory qualities and consumer acceptability with yam amala.

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