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Evaluation of Cocoyam-Soybean Flour Blends and Sensory Properties of the *Amala* Dumpling

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Abstract

Amala, a staple food among the Yoruba people of South West Nigeria, is mostly produced from yam. Since yam is known to be mostly carbohydrate and soybean is a legume with an appreciable quantity of protein, efforts have been made to prepare *amala* from the blends of cocoyam and soybean flours. The protein content of the flour blends ranged from 3.73% to 13.81%. In general, there was increase in the concentration of protein with increasing level of soy flour substitution. Unlike protein, the crude fibre content of the flour blends decreased with increasing supplementation of soy flour. Increase in oil content of the flour samples, with increasing addition of soy flour, predisposes the samples to shorter shell life and off flavor because of liability to rancidity. The lowest bulk density of 0.78 g/cm^3 was recorded for sample A (100% cocoyam flour) and hence none of the flour blends could be considered as a complimentary infant substitute. In general, supplementation of cocoyam flour with soy flour enhanced the concentrations of protein, ash and dietary fibre. Therefore, it is hoped that consumption of cocoyam *amala* supplemented with soy flour, a cheap source of plant protein, will not only create dietary diversity, it will make more protein available for the consumers and thus help in alleviating the problem of protein energy malnutrition in developing regions of the world.

Keywords: Cocoyam, Soybean, Flour blends, *Elubo*, *Amala* dumpling.

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Contribution of this paper to the literature:
This study reveals the possibility of using the blends of cocoyam and soybean flours to produce *amala* which hitherto is produced from white yam species. Supplementation of cocoyam flour with soybean flour for the production of *amala* creates dietary diversity, makes nutritionally important nutrient such as protein more available and widen the scope of utilization of cocoyam which is traditionally believed to be a food crop for low-income group.

1. Introduction

Cocoyam (*Colocasia esculenta*) is a well-known food plant that is high in carbohydrates [1]. It is a member of the *Araceae* family [2]. A significant proportion --- about 75%, of the world production of cocoyam comes from Africa, with Nigeria and Ghana leading the way. Cocoyam is the third most important root and tuber crop in Nigeria, following yam and cassava though consumption of cocoyam is assumed to be for low income earners of the society in some communities because it is readily available at a relatively lower price [3, 4]. Cocoyam is nutritionally superior to other root and tuber crops [5]. It contains more crude protein than other root and tuber crops, and its starch is highly digestible due to the small size of the starch granules. In addition, it contains calcium, phosphorus, vitamin A, and B-vitamins [6]. Cocoyam is an underutilized tropical root plant in Nigeria, its utilization is still at the subsistence level, making it a highly neglected crop [7]. In the South Eastern part of Nigeria, cocoyam flour is commonly used as a thickener in soup preparation. Cocoyam has been reported to have a lowering effect on blood glucose levels, confirming its anti-hyperglycemic effect and thus recommended for diabetic patients [8]. The nutritional and chemical compositions of cocoyam indicate that, if fully exploited, it would improve food and nutrition security for people living in the tropics [9].

Soybean (*Glycine max*) is a leguminous plant that is widely grown for its edible seed, which has numerous uses. Seeds of soybean have an outstanding nutritional and functional food profile. Based on their nutrient composition, soy-foods are considered nutritious and healthy [10]. It is the only plant source that contains all of the essential amino acids; the protein content of soybeans is higher than that of other legumes. Soy protein is also high in quality and easily digestible. Soybeans are high in fat, with the majority of the fatty acids being unsaturated. Polyunsaturated (primarily linoleic acid), monounsaturated (oleic acid), and saturated (primarily palmitic acid) fatty acids account for approximately 63%, 23%, and 14%, respectively. Soybeans have a high polyunsaturated fat content, which includes alpha-linolenic acid, an essential omega-3 fatty acid. Soybeans are one of the few plant foods that contain both essential fatty acids, B-vitamins, calcium, iron, and phosphorus are among the vitamins and minerals found in soybeans [10]. It also contains antioxidants and phytonutrients, like phytosterols and phytoestrogens, which have been linked to a variety of health benefits. Soybean is one of the cheapest and richest sources of plant protein that can be used to help millions of people meet their nutritional needs. Aside from being a good source of protein, the seed is said to have the highest food value of any plant food consumed worldwide [10]. Soybean contains protein (35–45%), oil (15–25%) and carbohydrate content is approximately 33%, out of which 16.6% are soluble sugars [11]. It also contains approximately 19.10% ether extract, 5.71% crude fibre, 5.06% mineral content, and 26.05% nitrogen free extract [12].

Amala is a popular Yoruba starchy food made by mixing yam flour (*elubo*) with boiling water and vigorously stirring with a wooden stirring rod until a smooth, consistent paste is formed. Continuous and vigorous stirring is required to prevent the formation of lumps. *Amala* is rolled into balls between the fingers and served with a variety of soups and stews that contain fish or meat. It is a meal that can be consumed at any time of day. *Amala* is a popular delicacy in Western Nigeria and other West African countries. *Amala* is traditionally made mainly from yam flour (*elubo*) although the use of cassava flour *(lafun*) and unripe plantain flour (*elubo ogede*) is not uncommon. Yam flour (*elubo*) is made from yam tubers, primarily white yam (*Dioscorea rotundata*) [13]. Efforts have recently been made to produce flour from other roots and tubers, such as potato and cocoyam, that can be used to make *amala*. Furthermore, because *amala* is a high-carbohydrate food, several studies have been conducted to improve the nutritional quality of this commonly consumed meal. Abulude and Ojediran [14] supplemented yam flour (*elubo*) with soybean flour in 2006, and Barine and Frankline [15] produced composite flour from a blend of yam and African yam beans ((*Sphenostylis stenocarpa*)), both for *amala* preparation. Reports exist in the literature on the use of cocoyam and cocoyam-cowpea flour blends for preparation of *amala* [16, 17]; paucity of information on the use of cocoyam flour blended with soybean seeds at varying proportions necessitated this study. In this report, *amala* was made from a blend of cocoyam flour and soy flour, and the *amala* dumpling made from it was evaluated. This will, hopefully, make a significant contribution to the level of progress being made in using mixtures of local crops to improve nutrition in developing countries; it will also encourage diverse use of locally grown food crops [18].

2. Materials and Methods

2.1. Materials

Freshly harvested cocoyam was obtained from Ganmo Market, Ilorin, Kwara State, Nigeria while soybean was obtained from Sabo Market, Ogbomoso, Oyo State, Nigeria. Other equipment such as cabinet dryer, weighing balance, milling machine, trays and vats were provided by the Department of Food Science, Ladoke Akintola University of Technology, Ogbomoso, Oyo State, Nigeria.

2.2. Production of Cocoyam Flour

Cocoyam tubers were washed in water to remove dirts. The tubers were weighed, manually peeled with the aid of a stainless-steel knife and sliced into thickness of about 1.0 – 1.5 cm. The sliced cocoyam was blanched at 70 °C for 3 minutes and left in blanching water for 12 h while the water cools down to room temperature. The slices were then drained and dried in a cabinet dryer at 55 °C until it is properly dried. The slices were then milled using a plate mill. The milled sample was allowed to cool, packaged in a cellophane bag and stored on the laboratory shelf prior to further processing.

2.3. Production of Soybean Flour

The method of Udofia, et al. [19] was modified for use. Soybean was dried cleaned by winnowing and then washed with clean water. The seeds were then soaked in water for 4 h. The seed coat was removed by rubbing the soaked seeds between the palms of the hands. The decorticated seeds were dried in cabinet dryer at 55 °C until properly dried and then milled using a plate mill. The milled sample was packaged in a cellophane bag prior to further processing.

2.4. Formulation of Flour Blends

Elubo samples were prepared by blending cocoyam and soybean flours in the ratio of 100:0 (A), 95:05 (B), 90:10 (C), 85:15 (D), 80:20 (E), 75:25 (F) and 70:30 (G). The blends were similar to the preparation of Julianti, et al. [20].

2.5. Preparation of amala

The blend product (*elubo*) was prepared for consumption by pouring slowly and stirring continuously in boiling water with a wooden rod while being cooked. The stirring was done vigorously to prevent formation of lumps and a smooth consistent paste was formed. The paste was covered and left to steam on the fire for about 5 minutes to cook. It was further stirred, packed and wrapped in sweet prayer (*T. daniellie*) leave. Each of the flour blends was used to prepare *amala* using this same procedure.

2.6. Determination of Proximate Analysis of Cocoyam-Soybean Flour Blends

The proximate analysis of the cocoyam-soybean flour blends (samples A, B, C, D, E, F and G) were carried out using standard methods [20]. The proximate parameters determined were total ash, moisture content, crude protein, crude fat (ether extract), crude fibre and total carbohydrate. The total carbohydrate was determined by difference.

2.7. Determination of Functional Properties

Water and oil absorption capacities were determined using centrifugal method. Distilled water was used as a medium for water absorption while refined olein was used for oil absorption [21, 22]. Bulk density for each of the flour blends was determined using the method described by Ojo and Ade-Omowaye [23].

2.8. Sensory Evaluation

Sensory evaluation of the *amala* samples was carried out for taste, color, aroma, texture, and general acceptability. The sensory evaluation was done by 10 panelists who were provided with questionnaire with nine-point Hedonic Scale. Each panelist was requested to assess each coded sample and to record the degree of differences.

2.9. Statistical Analysis

Statistical analyses of the data obtained were done using the Statistical Package for Social Science (SPSS version 16.0) [24]. The data were subjected to one-way analysis of variance and the significance difference determined at $p>0.05$. The means were separated by Duncan multiple range test.

3. Results and Discussion

3.1. Proximate Composition of Cocoyam-Soybean Flour Blends

The results of the proximate composition of the composite flour blends of cocoyam and soybean are shown in Table 1. The moisture content of flour blends ranged from 5.82 to 7.64% .

Table 1. Proximate composition of cocoyam and soybean flour blends.

Sample	Moisture (%)	Ash (%)	CHO (%)	Crude fat (%)	Crude fibre (%)	Crude protein (%)	Calorific value (cal)
A	7.64 ± 0.60^{b}	2.94 ± 0.37^{a}	82.18 ± 0.97^{d}	1.78 ± 0.42^{a}	3.02 ± 0.14^{ab}	3.73 ± 0.00^{a}	1624.60 ± 17.54^{a}
B	6.32 ± 0.52^{a}	2.97 ± 0.40^{a}	77.35 ± 1.31^{c}	2.97 ± 0.21^{b}	2.48 ± 0.44^{abc}	8.16 ± 0.00^{a}	1619.12 ± 22.53^{b}
C	6.69 ± 0.31^{b}	3.03 ± 0.19^{ab}	72.63 ± 0.21^{b}	3.58 ± 0.23^{c}	2.32 ± 0.18^{a}	12.47 ± 0.00^{a}	1590.61 ± 4.90^{b}
D	6.32 ± 0.76^{a}	3.11 ± 0.14^{ab}	73.38 ± 1.13^{b}	4.14 ± 0.08^{d}	2.27 ± 0.26^{d}	9.33 ± 0.00^{a}	1533.11 ± 22.08^{b}
E	6.06 ± 0.07^{a}	3.36 ± 0.09^{ab}	73.48 ± 0.15^{b}	5.34 ± 0.21^{e}	2.20 ± 0.11^{ab}	10.05 ± 0.00^{a}	1520.22 ± 1.80^{c}
F	6.22 ± 0.16^{a}	3.47 ± 0.11^{ab}	66.44 ± 0.47^{a}	7.75 ± 0.16^{g}	1.82 ± 0.57^{bc}	13.81 ± 0.00^{a}	1515.20 ± 1.94^{c}
G	5.82 ± 0.36^{a}	3.58 ± 0.23^{a}	66.74 ± 0.31^{a}	7.46 ± 0.00^{f}	1.75 ± 0.21^{c}	13.81 ± 0.00^{a}	$14.99.20 \pm 5.13^{c}$

Note: Values with different superscript along the same column are significantly different at $p>0.05$.
CHO = Total carbohydrate; A = 100% cocoyam flour; B = 95% cocoyam flour + 5% soybean flour; C = 90% cocoyam flour + 10% soybean flour; D = 85% cocoyam flour + 15% soybean flour; E = 80% cocoyam flour + 20% soybean flour; F = 75% cocoyam flour + 25% soybean flour; G = 70% cocoyam flour + 30% soybean flour.

With sample G having the lowest moisture content while sample A has the highest value. Flour samples with high moisture content greater than 12% usually have short shelf stability compared with the ones with lower moisture content of less than 12% [25].

The control sample i.e., 100% cocoyam flour, had the ash content of 2.94%. Addition of 5% soybean flour caused sample B to have 2.97% ash. The highest concentration of ash of 3.58% was recorded for sample G with 30% addition of soybean flour. Samples C, D, E and F had ash contents of 3.03, 3.11 and 3.36%, respectively. The results showed that there was increase in the ash contents of the flour blends with increasing addition of soybean flour. Thus, addition of soybean flour contributed to the increase in the ash contents of the flour blends. In an earlier study, Awolu and Oseyemi [1] reported increase in ash content in the range of 0.53 – 2.48% on addition of bambara groundnut to cocoyam flour.

The significant difference ($p>0.05$) in the protein content among the flour blends are presented in Table 1. The protein content of the flour blends ranged from 3.73% for the control to 13.81% for sample F and G. Sample E, containing 20% level of substitution with soy flour had 10.05% protein while sample D had 9.33% protein. In general, there was increase in the concentration of protein with increasing level of soy flour substitution. Increase in oil content of the flour samples predisposes the samples to shorter shell life and off flavor because of liability to rancidity. Protein is required for growth, repair and maintenance of fluid and strong immune system [26]. Protein also acts as a carrier for other nutrients such as iron, sodium, potassium [27]. Foods containing protein of good biological value are of great nutritional importance in developing regions of the world where is prevalence of protein energy malnutrition [19, 28]. In an earlier study, supplementation of cocoyam flour with bambara groundnut flour had been reported to cause increase in protein content [1]. It can therefore be inferred that flour blends of cocoyam and soy flours n the proportion formulated in this study can be used to produce *amala* dumpling rich in protein.

The 100% cocoyam flour contained 1.78% crude oil. The quantity of oil in the flour blends increased with increasing addition of soy flour. This is not unexpected because soy bean seed is an oil bearing leguminous seed. As shown in Table 1, 30% level of substitution resulted in 7.75% crude oil content of the flour blend indicating that soybean contributed significantly to the crude oil content of the flour blends. Increase in oil content of the flour samples predisposes the samples to shorter shell life and off flavor because of liability to rancidity [29].

Sample A contained 3.02% crude fibre. Samples B, C and D contained fibre content of 2.48, 2.32 and 2.27%, respectively while sample G had the lowest percentage of 1.75%. Unlike protein, the crude fibre content of the flour blends decreased with increasing supplementation of soy flour. Crude fiber content of the food product is an index to detect adulteration of flours [30]. Dietary fiber has been shown to have a great impact on the health of the consumers. Consumption of foods that are rich in dietary fibre is very essential due to its bulk addition to food, prevention of constipation and facilitation of peristalsis [31]. However, the crude fiber content of the flour blends in this study fall below the daily allowance range of 25-50% recommended by American Diabetes Association [32].

Cocoyam had been reported to be a good source of carbohydrate ranging from 72.0 to 87.7% [2]. This is comparable with the range of 66.74 to 82.18% obtained for the flour blends in this study. There was decrease in the total carbohydrate content of the flour blends on increasing addition of soy flour. Calorific value ranged from 1499.20 calorie for sample G to 1624.60 calorie for sample A. Thus, calorific value decreased with increasing supplementation with soy flour. The energy value of food is very important as it helps to determine the fuel value of food. Energy is not a nutrient but is required for metabolic process, physiological functions, heat production, muscular activity, synthesis of new tissues and growth. Energy is released from food components by oxidation [33].

3.2. Functional Properties of Flour Blends

The functional properties of the flour blends are shown in Table 2. Water absorption capacity ranged from 107.51 for sample A to 135.23 for sample G. There was significant difference ($p > 0.05$) among all samples. Water absorption capacity is the ability of a product to absorb water [34]. Similar observations were observed for oil absorption capacity of the samples. Increase in the water absorption capacity with increasing addition of soybean flour might not be unconnected with the increase in the lecithin content of the flour blends occasioned by the addition of soybean flour. Addition of lecithin has the propensity to hold cause increase in water absorption capacity. Good water absorption capacity of these flour blends makes them ideal for preparation of dumpling such as *amala*. The highest bulk density of 0.95 g/cm^3 was recorded for sample G while sample A has the lowest bulk density of 0.78 g/cm^3. In 2015, Kiin-Kabari, et al. [35] reported bulk density of 0.34 g/ml for whole wheat flour. The high bulk density of these flour blends made them unfit to be used as weaning foods. Weaning foods are expected to have bulk density of less than 0.6 g/cm^3. Low bulk density is of benefit in the formulation of infant complementary foods [36].

Table 2. Functional properties of cocoyam and soybean flour blends.

Sample	Absorption property		Bulk density
	OAC (%)	WAC (%)	(g/cm^3)
A	61.37 ± 1.34^a	107.51 ± 0.82^a	0.78 ± 0.01^a
B	66.07 ± 2.63^b	115.20 ± 2.20^b	0.81 ± 0.02^{ab}
C	67.44 ± 2.14^b	116.75 ± 1.54^{bc}	0.83 ± 0.00^b
D	67.40 ± 2.90^b	122.45 ± 0.06^{cd}	0.87 ± 0.01^a
E	68.57 ± 3.59^{bc}	126.24 ± 2.19^d	0.93 ± 0.02^d
F	76.49 ± 1.34^d	134.70 ± 2.70^e	0.93 ± 0.01^d
G	76.91 ± 3.40^d	135.23 ± 2.23^e	0.95 ± 0.01^d

Note: Values with different superscript along the same column are significantly different at p>0.05.
WAC = Water absorption capacity; OAC = Oil absorption capacity.
A = 100% cocoyam flour; B = 95% cocoyam flour + 5% soybean flour; C = 90% cocoyam flour + 10% soybean flour; D = 85% cocoyam flour + 15% soybean flour; E = 80% cocoyam flour + 20% soybean flour; F = 75% cocoyam flour + 25% soybean flour; G = 70% cocoyam flour + 30% soybean flour.

Table 3. Sensory evaluation of *amala* from cocoyam and soybean flour blends.

Sample	Colour	Appearance	Taste	Flavor	Texture	General acceptability
A	6.20±0.27^a	6.85±0.13^a	6.45±0.26^a	5.75±0.18^a	6.15±0.25^a	6.35±0.25^a
B	6.90±0.32^{ab}	6.70±0.21^a	6.60±0.37^a	5.90±0.35^a	6.50±0.24^a	5.90±0.37^b
C	6.80±0.34^a	6.25±0.32^a	6.55±0.39^a	6.75±0.33^a	6.80±0.24^a	6.85±0.36^b
D	6.95±0.29^a	7.05±0.30^a	7.40±0.30^a	6.55±0.26^a	6.35±0.31^a	7.30±0.24^{ab}
E	6.75±0.33^a	6.65±0.35^a	6.35±0.41^a	6.30±0.36^a	6.10±0.30^{ab}	6.20±0.34^{ab}
F	5.70±0.31^a	5.85±0.29^a	5.75±0.26^b	5.80±0.28^a	5.35±0.31^a	5.35±0.30^{ab}
G	5.60±0.21^{ab}	6.00±0.23^{ab}	5.69±23^{ab}	5.90±0.28^a	5.75±0.34^a	5.35±0.23^{ab}

Note: Values with different superscript along the same column are significantly different at p>0.05.
A = 100% cocoyam flour; B = 95% cocoyam flour + 5% soybean flour; C = 90% cocoyam flour + 10% soybean flour; D = 85% cocoyam flour + 15% soybean flour; E = 80% cocoyam flour + 20% soybean flour; F = 75% cocoyam flour + 25% soybean flour; G = 70% cocoyam flour + 30% soybean flour.

3.3. Sensory Evaluation of Amala from Flour Blends

The results obtained for the sensory evaluation of *amala* dumpling from the blends of cocoyam and soybean flours are shown in Table 3. In term of colour appearance, taste and flavour, samples B, C, D and E compared favourably well with sample A (100% cocoyam flour). Increased substitution with soybean flour at 30% caused significant difference in the texture of the *amala* dumpling. *Amala* prepared with 15% level of soybean substitution appeared to be more acceptable to the panelist. There was a significant change in texture with 30% substitution. Sample D is more preferable to every other sample when consideration for taste, appearance and colour are of importance. *Amala* prepared from sample D, with 15% soybean flour substitution, is the most preferable *amala* dumpling.

4. Conclusion

Amala from the blends of cocoyam and soybean was produced and evaluated. The results of the proximate composition of the flour blends showed that supplementation of cocoyam flour with soy flour enhanced the concentrations of protein, ash, oil and dietary fibre. Improvement in some functional properties on supplementation with soy flour gives a propensity that the flour blends might be useful for other food preparations such as palp or as an adjunct component of bakery products. Encouraging increasing consumption of cocoyam *amala* supplemented with soy flour, a cheap source of plant protein, will not only create dietary diversity, it will make more protein available for the consumers and thus help in alleviating the problem of protein energy malnutrition particularly in developing regions of the world.

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