



## **Nutritional Composition of Flour Blends from Water Yam, Yellow Maize and African Yam Bean**

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### **Authors' contributions**

*This work was carried out in collaboration among all authors. Author CEK designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors ICA and FCE managed the analyses of the study. Author CEK managed the literature searches. All authors read and approved the final manuscript.*

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### **ABSTRACT**

Adequate and proper understanding of the nutritional composition of different flour materials is important in their use in the production of baked food materials. The proximate composition of water yam-yellow maize and African yam bean flour mixtures was therefore evaluated in this study. Standard procedure for dry-milling unit operation was used in the flour processing. Flour samples were blended in different ratios to form the following composite samples: AFK which comprised of 30% water yam (WY):40% yellow maize (YM):30% African yam bean (AYB); BGL which comprised of 40%WY:30%YM:30%AYB CHM comprising of 50%WY:20%YM:30%AYB; DIN comprising of 60%YM:10%YM:30%AYB and control treatment comprising of 100%WY. Crude protein content ranged from 4 to 22.50%; fat content ranged from 1.80%; ash content ranged from 7.00%; moisture content ranged from 6.00 to 10.00% carbohydrate content ranged from 50.43 to 80.90% and energy

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content ranged from 331.50 to 356.35%ked. Addition of yellow maize and African yam bean statistically ( $p < 0.05$ ) increased the protein, fat, fibre, ash, moisture and energy content of flour blend but statistically ( $P < 0.5$ ) reduced the carbohydrate content. Flour sample DIN found to be adequate for both children and adult consumption of the flour when compared to the Codex Alimentarius Commission [1].

*Keywords: Nutritional composition; flour; water yam.*

## 1. INTRODUCTION

The low protein intake in most African countries including Nigeria has been attributed to the increasingly high cost of animal protein drug side inadequate utilization of most plant protein sources. This situation aggregates widespread malnutrition which is maintained more in the vulnerable groups such as children and mothers (especially expectant and lactating). Nowadays, emphasis are now placed on the identification and utilization of traditional plant protein which are cheaper than proteins from animal sources to enrich the starchy foods, for combating malnutrition soybean has always been targeted because they are in expensive protein source used in supplementing various novel food products. However, there are several other legumes whose utilization is still very low though their potential is high. Among them is African yam bean which has high protein content (19.6 – 29% reported by Eka and Akaninwo [2]. African yam bean is one of the lesser known legumes produced in Nigeria and has high amino acid composition particularly lysine and methionine which is equal or higher than those of soybean [3,4]. AYB has exceptional ability of adapting to low land tropical soil conditions with high yields (although it contains anti-nutritional factors and the processed products do not give serious health problem. Yam belongs to the order lilliales, family dioscoreacea which are not edible (Eke, 1990). Yam is a staple food for millions of people in the world, providing an important source of carbohydrate and more protein on dry weight basis than is commonly assumed (IITA, 1992). The problem in yam production are high cost of seed yam, high labour requirement, disease and pests as well as post-harvest losses [5]. Consequently, about 30% of harvest yam tubers are diversified usages, especially industrial utilization and human consumption (Uzodinma et al. 2016). Generally water yam contains less sugar and have an extended shelf life (Romain and Raemakers, 2001) which ensures availability in periods of scarcity. It is known for its high nutritional contents with moisture [6,7]. Cereal

grains are eaten in several ways and in most cases; they are milled into flour and utilized in preparing various. Maize (yellow maize) is a cereal crop widely cultivated in Nigeria and the tropics. It is used in the production of various food items such as Ogi (Akamu) Agidi custard. Considering the prevalence of nutrition-related health problems among Nigerians, there is therefore an increasing need for a more complete, accurate, reliable data on the nutrient content and nutritional value of local foods. This work was undertaken to evaluate the nutrient composition of mixture of water yam yellow-maize and African yam bean flour blends.

## 2. MATERIALS AND METHODS

The water yam was identified as TDA 297 and bought at national root crop research institute (NRCI), Umudike, Abia State, Nigeria. The yellow maize and the cream colour African yam bean were identified and bought at national institute of horticulture (NIHOT) Mbato sub zone, Okigwe, imo state. Xanthan gum (G 1253, sigma-aldrich USA) was procured from pharmaceutical shop in Onitsha, Dangote iodized table salt was purchased from a food shop in Eke Market in Afikpo, Ebonyi State, Nigeria.

### 2.1 Preparation of Raw Materials

#### 2.1.1 Water yam flour

Water yam was washed, peeled manually under water containing 0.20% solution of sodium metabisulphate. Slicing of the water yam (3 mm x 5 mm) was done with a stainless knife, the transferred into another container of the same concentration of sodium metabisulphate and allowed for 5 min. The sliced water yam were removed and allowed to drain for thr under air current and dried at 60°C for 6 hrs in a chirana type air convection oven (HS201A). Dried chips were cooled for 2 hr at room temperature under air current and milled using Brabender roller mill (Model 3511A). The flour sample was sieved through 0.50 mm mesh size, packaged and sealed in polyethylene bag for further use.

### 2.1.2 African yam bean flour

The cream coloured African yam bean seeds were sorted and cleaned in an aspirator (Model: OB 123 Bindapst Hungary) located at the food processing laboratory of federal polytechnic, mubi cleaned seeds were soaked for thr at room temperature. The seeds were sundried for 4 days at ( $30^{\circ}\pm 2^{\circ}\text{C}$ ) and milled with Brabender roller mill (Model 3511A) to pass through screen with 0.50 mm openings. And resulting coarse meal were re-milled into fine flour. The flour was stored in an air tight plastic container at room temperature for further use.

### 2.1.3 Yellow maize flour

The yellow maize grain were sorted, and cleaned in an aspirator (Model OB 125 Bindapst Hungary) located at the food processing laboratory at federal polytechnic, Mubi to eliminate contaminants. The cleaned maize grains were conditioned at  $40^{\circ}\text{C}$  for 30 mm in a stainless steel container. The seeds were sundried for 4 days at ( $30^{\circ}\pm 2^{\circ}\text{C}$ ) and then cracked and milled with Brabender roller mill (Model 3511A). The seed coats were removed to obtain the maize flour to pass through a screen with 0.50 mm openings and resulting coarse meal were re-milled into fine flour. The flour was stored in an air tight plastic container at room temperature for further use.

## 2.2 Flour Blending Ratio

The flours from the water yam, yellow maize and African yam bean (AYB) were blended in the ratio as shown below.

## 2.3 Analytical Procedure

The flowing analyses were carried out in triplicate or sample extracts of water yam, yellow maize and African yam bean flour blend.

Chemical Analysis: proximate composition of the flour samples was determine using the official methods of AOAC [8]. Carbohydrate was determine by different food energy values were determined by calculation using the at water [9] factor (4 x protein, 9 x fat and 4 x carbohydrate) amino acid profile was determined as described [10,11].

## 2.4 Statistical Analysis

The experimental design was a 3 x 3 factorial in Complete Randomized Design (CRD) where the

three flour sources and their combination ratios were the two factors under consideration. Data generated from the study were subjected to Analysis of Variance (ANOVA) and means separated using FLSD 0.05 with SPSS version 22.0

## 3. RESULTS

### 3.1 Proximate Composition of Water Yam Yellow Maize and African Yam Bean Flour Blends

Results of proximate composition of water yam yellow maize and African yam bean flour blend are shown in Table 2. The value of crude protein ranged from 4.00 to 22.50%, with flour sample DIN (60% WY:10%YM:30%AYB) having the highest crude protein content, while the flour sample EJO (100% WY) had the least crude protein content. All the flour samples were statistically ( $p<0.05$ ) different from each other in their crude protein contents.

The value of the fat content ranged from 1.10 to 5.29%, with flour sample CHM (50% WY:20%YM:30%AYB) having the highest oil content, while the flur from sample EJO had the least oil content. Flour samples BGL and DIN did not differ ( $p>0.05$ ) statistically from each other, but both differed ( $p>0.05$ ) statistically from other flour samples. The value of the crude fibre ranged from 1.00 to 1.80%, with flour sample from sample BGL (40% WY:30% YM:30%AYB) having the highest curdefibre content, while the flour sample EJO had the least crude fibre content. Samples AFK (30% WY: 40%YM:30%AYB), CHM and DIN were not statistically ( $p>0.05$ ) different from one another, but were statistically ( $p<0.05$ ) higher than flour sample EJO and lower than flour sample BGL respectively. Increase in yellow maize in the composite flour might have resulted to increase in fibre content. The value of the ash content ranged from 7.00 to 10.00% with flour samples AFK and BGL having the highest ash contents respectively, while the flour samples AFK and BGL but both differed ( $p<0.05$ ) statistically from all other flour samples in ash content. The value of moisture content for the ranged from 6.00 to 10.00%, with flur blend from sample AFK having the highest moisture content, while flour sample EJO had the least moisture content. Samples BGL, DIN AND EJO were not statistically ( $p>0.05$ ) different from one another, but were statistically ( $p<0.05$ ) lower than other flour samples.

**Table 1. Flour blending ratio**

Coded samples	WY(%)	YM (%)	AYB(%)	Total (%)
AFK	30	40	30	100
BGL	40	30	30	100
CHM	50	20	30	100
DIN	60	10	30	100
EJO	100	0	0	100

Sample EJO = Control (100%) Water Yam, WY = Water Yam, YM = Yellow Maize, AYB = African Yam Bean,  
 AFK = 60% WY: 40% YM: 30% AYB  
 BGL = 40%WY: 30%YM: 30% AYB  
 CHM = 50% WY: 20% YM: 30% AYB  
 DIN = 60%WY: 10%YM: 30%AYB  
 EJO= 100% WY

**Table 2. Nutritional composition and energy content of water yam, yellow, maize and african yam, bean flour blend**

Sample	Protein (%)	Fat (%)	Fibre (%)	Ash (%)	Moisture (%)	Carbohydrate (%)	Energy (Kcal)
AFK	15.00 <sup>d</sup> ± 0.50	3.42 <sup>c</sup> ± 0.02	1.40 <sup>b</sup> ± 0.20	10.00 <sup>a</sup> ± 0.50	10.00 <sup>a</sup> ± 0.50	60.18 <sup>b</sup> ± 0.20	331.50 <sup>ab</sup> ± 0.10
BGL	20.25 <sup>c</sup> ± 0.25	4.35 <sup>c</sup> ± 0.00	1.80 <sup>a</sup> ± 0.05	10.00 <sup>a</sup> ± 0.50	6.00 <sup>c</sup> ± 0.50	57.60 <sup>c</sup> ± 0.10	350.55 <sup>ab</sup> ± 0.02
CHM	21.88 <sup>b</sup> ± 0.01	5.29 <sup>a</sup> ± 0.00	1.40 <sup>b</sup> ± 0.05	9.90 <sup>a</sup> ± 0.20	8.00 <sup>b</sup> ± 0.10	59.43 <sup>d</sup> ± 0.01	336.80 <sup>ab</sup> ± 0.10
DIN	22.50 <sup>a</sup> ± 0.10	4.31 <sup>b</sup> ± 0.00	1.30 <sup>b</sup> ± 0.05	9.00 <sup>b</sup> ± 0.50	6.10 <sup>c</sup> ± 0.10	56.89 <sup>c</sup> ± 0.00	378.80 <sup>a</sup> ± 0.10
EJO	4.00 <sup>c</sup> ± 0.20	1.10 <sup>d</sup> ± 0.10	1.00 <sup>c</sup> ± 0.10	7.00 <sup>c</sup> ± 0.20	6.00 <sup>c</sup> ± 0.00	80.90 <sup>a</sup> ± 0.00	349.50 <sup>b</sup> ± 57.73

Values are mean of triplicate determination ± standard deviation  
 Means with the same superscript within the column are not significantly ( $P > 0.05$ ) different from each other.  
 AFK = 60% WY: 40% YM: 30% AYB  
 BGL = 40%WY: 30%YM: 30% AYB  
 CHM = 50% WY: 20% YM: 30% AYB  
 DIN = 60%WY: 10%YM: 30%AYB  
 EJO= 100% WY

Addition of yellow maize and African yam bean might have increased the moisture content of the composite flour. The value of the carbohydrate content ranged from 50.43 to 80.90%, with flour sample EJO having the highest carbohydrate content, while the flour blend from sample CHM had the least carbohydrate content. The carbohydrate content of samples BGL and DIN were not statistically ( $p>0.05$ ) different from each other but both different maize, might have decreased the carbohydrate content of the composite flour. The value of the energy content ranged from 331 to 356.35 kcal, with flour sample DIN having the highest energy content, while the sample CHM had the lowest energy content. The energy content of sample EJO was statistically ( $p>0.05$ ) lower than other flour samples. Addition of yellow maize and African yam bean might have increased the energy content of the composite flour.

## **4. DISCUSSION**

### **4.1 Proximate Composition of Water Yam, Yellow Maize and African Yam Bean Raw Flours**

#### **4.1.1 Raw flour crude protein content**

The protein content of the raw flours and its blends ranged from 4.00 – 22.50%. The crude protein content of water yam flour in this study was found to be lower than the earlier reported values [12,13,14]. The protein content of composite flour values observed in this study was comparable to range of values reported by Idowu, [15] for maize- African yam bean seed, but lower than the values for the blends of maize tuwo – cirinaforda flour blends [16]. The high crude protein content of African yam bean might account for high protein content of the composite flour and the observation had been reported [17]. The protein content of the composite flours falls within the range of protein requirements for babies, which is 15% as recommend by Codex Alimentarius commission [1] and 10 – 12% protein for bread baking as reported by West et al. [18]. The observed increase in protein content obtained the composite flour is similar to the report of earlier researchers [19,14]. This might be attributed to the fact that African yam bean is reported to be nutrient –dense, having high protein content [20]. This is in line with the report of [21,15]. They suggested that fortification of low-protein cereal and roots and tuber foods with commonly consumed legumes will make such blend relevant in solving protein–energy

malnutrition in developing nations, resulting from high cost of animal protein. Limroongreungrat and Huang [22] used protein sources such as soy protein concentrate to enhance the nutritive quality of products. In their study, pasta fortified with 15 g/100 g defatted soy flour or 15% soy protein concentrate had approximately five times higher protein content compared to pasta made from 100 g/100 g alkaline treated sweet potato flour. In this study, the level of incorporation of African yam bean in the composite flour increased the protein content at least three folds.

#### **4.1.2 Raw flour fat content**

The crude fat content values of the raw flour ranged from 1.10% and 5.29% in this study are shown in Table 2.

The value of fat content of water yam observed in this study was higher than the values earlier reported [23,24]. The fat content obtained in the composite flour in this study were comparable to the range of values reported earlier (Lymo et al., 2007).

However the values reported in this study were lower than 10 to 20% recommended for the supplementary foods [25] the importance of fat content in the shelf – life of food products cannot be over emphasized as high fat content in processed for products are unwanted therefore, the low fat level in this flour blends is a appreciated and implies that the shelf – life of flour will not easily suffer rancidity. Yam generally has poor fat content as reported by [7] however, high level of fat is desirable due to increase in energy level of a diet. The fat content of the composite flour increased when compared to water yam flour. This is similar to the findings by [26] and is also expected as a general trend following complementation.

#### **4.1.3 Raw flour crude fiber content**

The crude fibre content values of the raw individual flour ranged from 1.00% and 1.80% in this study are shown in Table 2. Many researchers had reported higher values for water yam [27,24,23]. However, the value observed in this study were comparable to the range of value earlier reported by [28] it is clear that the fibre content of the composite flour increase with increased in proportion of other flours. However, the fibre content of the composite flour was below the range for weaning formulation but was sufficient for adult as

recommend by Protein Advisory Group [29]. A high intake of dietary fibre is positively related to different physiological and metabolic effects. It contributes less to calories and can bind and flush cholesterol and undesirable chemicals from the body.

It provides bulk, regulates intestine motility and thereby helps to prevent the development of diverticulosis and chronic disease including coronary heart disease and other disorders of the gastrointestinal lining. Woolfe [30] reported that yam flour has higher level of fibre than potato flour refined wheat flour, and rice. Intake of total dietary fibre, could therefore, be increase by the consumption of foods from water yam or by incorporating into other sensorial accepted foods [31].

#### 4.1.4 Raw flour ash content

The ash content values of the raw individual flour ranged from 7.00% and 10.00% in this study are shown in tables. Earlier researchers had reported lower values for different varieties of water yam [31,32]. Similarly, some researchers have reported lower range of ash content of composite flours [28,15]. The ash content of raw flour is an indication of the mineral present in the flour and is defined as the inorganic residue from the incineration of organic matter. The amount and composition of ash in a food product depend on the nature of the food ignited and on the method of ashing. The high value of ash content in the composite flour in this study could be as a result of the high ash content in the water yam flour [31] concluded that water yam had appreciable levels of phosphorus, calcium, potassium, zinc, manganese and copper. Expectedly, high ash content of food might be good for mineralized with health significances. It is clear that the ash content of the composite flour increase with increased with addition of other flours especially yam flour in this study.

#### 4.1.5 Raw flour moisture content

The moisture content values of the raw individual flour and the flour blends are shown in Table 2. The moisture content of the individual flour and their blends ranged from 6.00 – 10.00%. The value of water yam moisture content reported in this study was comparable to the values reported by other researchers [33,34, Udensi et al. 2008]. The result of the observed values for composite flour is in agreement with the report of Egbedike

et al. [14] who reported higher moisture content for flour blends. Meanwhile, the moisture content observed in this study was an indication of longer shelf life of the blends and this agreed with the findings of [35,16,28]. Moisture content of flour is very important for its shelf-life, the lower the flour moisture content the better the storage stability [36,37,38].

#### 4.1.6 Raw flour carbohydrate content

The carbohydrate content values of the raw individual flour and it blends 56.89 to 80.90% ranged from 50.33 to 80% in this study are shown in Table 2.

Water yam flour carbohydrate content in this study was comparable to earlier reported values [39,40]. However, Ezeocha and Ojimekwe [33] reported a lower value for carbohydrate content of water yam. Addition of full fat African yam bean flour in the blend while increasing the protein content of the composite flour lowered the carbohydrate content of the composition. Similar observation was made by Jimoh and Olatidoy (2009). The values of composite for snacks containing full fat African breadfruit- soy bean and corn [21]; furthermore, the carbohydrate content of the formulated composite flours in the this study is close to the range required for wheat flour for pasta making and weaning food mixtures on dry weight basis [18].

#### 4.1.7 Raw flour energy content

The energy content values of the raw individual flour and the blends were between 331.50 kcal and 378.80 kcal in this study shown in Table 2.

The observed energy content of water yam in this study was lower than the reported value by [33]. However, the observed energy value of the flour blend in this study was comparable to the range reported for maize Tuwo-cirinaforda flour blends [16] and for cocoyam – cassava – maize wheat – soybean flour [41].

The energy content in this study were within the recommended value of flour for bread baking.

West et al. [18] and for weaning food in accordance with codex Alimentarius [1] some properties of water yam such as starch and amylopectin contents are lower when compared with other species of yam (*D. rotundata*) as reported by Onwuka and Ihuma [42]. This obviously explains why nutritionsts recommend

the use of more water yam in diet therapy of diabetic patients than *D. rotundata* as water yam presents itself as a more tolerable energy source [9]. The results of this study showed that composite flour from water yam yellow maize. African yam bean (up to 30%) flour mixtures are good sources of energy and protein. This could be used to challenge energy –protein malnutrition which according to Aberoumand and Deokule, [43] is a major public health problem in developing countries.

## 5. CONCLUSION

Appropriate processing and blending of locally grown legumes, cereals and tubers (as in African yam bean AYB yellow Maize YM and water yam WY) especially at the ratio of 60% WY:10 YM:30% of AYB as seen in sample DIN) on the basis of nutrient complementivity could close the gap in protein-calorie malnutrition in children as well as adult consumers in Nigeria.

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## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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