



**Blends functionality, colour evaluation and proximate composition of flours from African Yam Bean (*Sphenostylis stenocarpa*), Millet (*Pennisetum glaucum*) and Tiger nut (*Cyperus esculentus*)**

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**Abstract**

The suitability of composite flours from underutilized crops in baking applications depends on the understanding of their functional and physicochemical properties. This study examined the effect of inclusion of African yam bean, millet and tigernut flours at varying levels of (100:0:0, 0:100:0, 0:0:100, 80:10:10, 70:20:10, 60:30:10 and 50:40:10). Seven (7) treatments were studied in a completely randomized design and the proximate composition, colour and functional properties of blends were determined. The highest carbohydrate, fat and protein content were found in millet, tigernut and African yam bean flours respectively. The composite blends had highest moisture, fat and fibre content in samples 60:30:10; 80:10:10 and 70:20:10, respectively. Protein, ash, and total energy of the blends decreased with increasing substitution level of millet. However, an increase in carbohydrate (6.09 %) was observed with increasing substitution level of millet. More so, decrease in degree of lightness (L\*) (27.9 %) and yellowness (b\*) (33.49 %) was observed with increasing substitution level of millet. This investigation has shown that the improved flours on ratio 80:10:10 could add value to Nigerian food industry for bakery application thereby reducing costs of wheat importation and reduce malnutrition in consumers especially children.

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**Introduction**

Single intake of legume, cereal or tuber cannot provide adequate amounts of all nutrients to meet nutritional requirements in consumer's diet. Even before knowledge on protein content, protein quality, digestibility and nutrient requirements of humans became available, it was recognized that mixing level of legumes, cereals, and tubers in the diet could improve overall nutrition and provide necessary attributes for consumer acceptance (Dendy, 1992). The introduction of composite flour to Africa especially Nigerian food industries would encourage agricultural sector and reduce wheat importation. In Nigeria, wheat importation is costly which led to increase in price of bakery products. However, substitution of flours majorly from cereals (wheat, pearl millet, sorghum, rice, maize), legumes (African yam bean, soybean, locust bean) and tubers (cocoyam,

tigernut, sweet potato) would replace wheat importation if practiced in Nigerian food industry.

Pearl millet mode of preparation is not well developed owing to short storage because it is oil-rich (Obilana and Manyasa, 2002) and loss of nutrients such as dietary fibre and phytochemical in the removal of bran and germ during milling (Shukla and Srivastava, 2011). Protein content in pearl millet is in close range with wheat (11 %) on a dry weight basis, rich in B vitamins (especially niacin, B6 and folic acid), calcium, iron, potassium, magnesium and zinc (USDA, 2012). Pearl millet contains no gluten, as it is not related to wheat; it is an appropriate food for those suffering from celiac disease or other forms of wheat gluten allergies/intolerance (Gelinias *et al.*, 2008). It is a potential source of nutraceutical such as antioxidant, phenolics and cholesterol-lowering waxes (Waniska *et al.*, 2002); magnesium and phosphorus which is

responsible for the reduction of migraine, and later is an essential component of Adenosine tri-phosphate (ATP) a precursor to energy in the body (Devi *et al.*, 2011). However, irrespective of the nutrients present in pearl millet, it is less-used comparing to other cereals and is often regarded as poor people's grains (Devi *et al.*, 2011). The consumption and utilization of pearl millet is mostly common in the Northern part of Nigeria and are usually made into *pap* with other grains or use as local drinks called *kunnu-zaki* and *fura* (Jideani *et al.*, 2011). Pearl millet is extremely versatile which can be consumed either by boiling/steaming, porridge, breakfast cereals, or mill into flour for baking in combination with legumes such as African yam bean (Jideani *et al.*, 2011).

Nutritionally, African yam bean (AYB) seed *Sphenostylis stenocarpa* is rich in protein ranging between 12 and 30 % (Nwosu, 2013; Ndidi *et al.*, 2014; Abioye *et al.*, 2015; Ade-Omowaye *et al.*, 2015; Duodu and Apea-Bah, 2017; Anya and Ozung, 2019). The proteins in AYB compares favorably with those in pigeon pea, chick pea, Bambara groundnut and common bean. It is also rich in dietary fiber (Ndidi *et al.*, 2014; Anya and Ozung, 2019), carbohydrates (Eromosele *et al.*, 2008; Ajibola and Olapade, 2016). Because AYB is rich in protein and other nutrients, it has been used in the development of fortified and enriched foods such as development of cookies and snacks (Idowu, 2014; Igbabul *et al.*, 2015), breakfast meals (Babarinde *et al.*, 2019), traditional snack food such as *kokoro* (Idowu, 2015b), maize – AYB meal composite (Idowu, 2015a), AYB enriched fufu (Aniedu and Aniedu, 2014), and weaning food produced from mung bean, pearl millet and tigernut flour blends (Iwe *et al.*, 2016).

Tigernut (*Cyperus esculentus*) is an underutilized readily available crop in Nigeria. The tuber contains significant amount of protein, fat, minerals and vitamins (Alobo and Ogbogo, 2007; Oladele and Aina, 2007). According to Chevalier (1996), tigernut could be used for the treatment of flatulence, indigestion, dysentery, diarrhea and excessive thirst. However, the use of underexploited crop to complement with legume (AYB) and cereal (pearl millet) in processing of composite flour would improve agricultural sector, reduce cost of wheat importation and reduce malnutrition. Therefore, the study was designed to evaluate blends functionality, colour evaluation and proximate composition of flours made from African yam bean, pearl millet and tigernut blends.

### Materials and Methods

African yam beans were gotten from a local market in Enugu, Enugu state; pearl millet and tigernut were purchased from Bodija Market in Ibadan Oyo state,

Nigeria. They were taken to the laboratory of Food Technology, University of Ibadan for further processing and analysis.

### Processing of African Yam Bean Flour

African yam bean was processed according to the method described by Enwere (1998). African yam beans were sorted manually to remove foreign materials. The seeds were soaked for 24 hours at room temperature, drained, rinsed, dehulled using cleaned mortar and pestle and oven dried at 55 °C for 15 hours. The dried beans were milled into flour using disc attrition mill. The flour obtained was sieved to pass through a 250 µm British standard sieve to obtain flour of uniform size. The flour sample was put in zip-lock bags and kept in covered plastic at 25 °C until further used.

### Processing of Pearl millet Flour

The pearl millet was processed according to the method (Odunfa and Adeyele, 1985). The grains were cleaned by sorting to remove stones and debris, washed with cleaned water and oven dried at 55 °C for 6 hours. The dried grains were milled into flour using attrition mill, sieved to pass through a 250 µm British standard sieve to obtain flour of uniform size. The flour sample was put in zip-lock bags and kept in covered plastic at 25 °C till further used.

### Processing of Tigernut Flour

Tigernut was processed according to the method described by Oladele and Aina (2007). The nuts were sorted and washed to remove stones and dirt, oven-dried at 55 °C for 6 hours. The dried nut was milled into flour using attrition mill, sieved to pass through a 250 µm British standard sieve to obtain flour of uniform size. The flour sample was put in zip-lock bags and kept in covered plastic at 25 °C until further analysis.

### Formulation of Composite Flours

The flour samples of African yam bean, pearl millet and Tigernut (%) were prepared by blending at varying ratios 80:10:10, 70:20:10, 60:30:10 and 50:40:10, respectively. The four different flour blends were prepared in the desired proportions using a laboratory scale mixer for 10 minutes at 10000 rpm. After blending, the flour samples were put in zip-lock bags at 25 °C until further analysis. The formulations of African yam bean, pearl millet and tigernut flours are shown in Table 1.

### Chemical Analysis

#### Proximate Composition of Blends

Proximate analysis including moisture content, crude protein, crude fat, total ash and crude fibre for raw materials and flour blends were determined using standard methods of Association of Official Analytical

Chemist (AOAC, 2010) and carbohydrate was calculated by difference.

Table 1 Formulations of African yam bean, pearl millet and tigernut flour blends (%)

Samples	African yam bean	Pearl millet	Tigernut
ORM	100	0	0
LFJ	0	100	0
CRQ	0	0	100
RPA	80	10	10
TSE	70	20	10
JLX	60	30	10
RPO	50	40	10

$$\% \text{ moisture content} = \frac{\text{Initial weight} - \text{Final weight}}{\text{Initial weight}} \times \frac{100}{1} \dots\dots\dots (1)$$

**Determination of Total Ash**

About 3 grams of samples was weighed into a crucible, cooled in a dessicator and weighed. Both the crucible and content was transferred into a muffle furnace ignited at 550 °C and ashed for 4 hours. Crucible and ashed sample was removed from the muffle furnace and cooled in a dessicator to room temperature. The crucible and its content was weighed and calculated as percentage ash using this expression:

$$\% \text{ Ash content} = \frac{(W_3 - W_1)}{(W_2 - W_1)} \times \frac{100}{1} \dots (2)$$

Where: W<sub>1</sub> = weight of dish; W<sub>2</sub> = weight of dish + sample before ashing; W<sub>3</sub> = weight of dish + sample after ashing

**Determination of Crude Fat**

The fat content was determined by extraction of fat using petroleum ether with the aid of soxhlet extractor for 6 hours. Two grams of sample was wrapped in a filter paper and placed in the thimble of the extractor. After the extraction was completed, the petroleum ether was recovered for use. The flask with fat was dried in an oven at 105 °C for 30 minutes, cooled and weighed. Percentage fat content was determined by the following equation;

$$\% \text{ Total Nitrogen} = \frac{(\text{Titre} - \text{Blank}) \times \text{Normality of acid} \times N_2}{\text{Weight of sample}} \dots\dots\dots (4)$$

Where: Nitrogen factor = 6.25; Crude protein = % total N x 6.25

**Determination of Crude Fibre**

Three grams of sample was weighed into beaker and 200 mL hot 1.25 % concentrated tetraoxosulphate (vi) acid was added and then place in digestion apparatus with pre-heated plates. The sample was boiled in reflux for 30 minutes in other to hydrolyze the carbohydrates and protein, followed by filtering through Whatman filter paper and thus washing of the residue with distilled water until the filtrate is neutral. The residue was transferred into the beaker and 200 mL 1.25 % NaOH was added before returning it to the digestion apparatus, boil and reflux for 30 minutes, allowed to stand for 5 minutes, filtered and washed with boiling water until filtrate is neutral. The residue was transferred into a

**Determination of Moisture Content**

A Sartorius moisture analyzer MA-30000V3 (Göttingen, Germany) was used to determine the moisture content of the raw material flours and blends. Analysis was performed based on Equation 1. The moisture analyzer was warmed up for at least 30 minutes; approximately 1 gram of sample was evenly spread on the tarred aluminum pan. Analysis was performed in the fully automated mode at 110 °C. The principle behind this analyzer is that, it determines the weight loss of the sample simultaneously as heat dries the sample using infrared dark radiator tubes.

$$\% \text{ crude fat} = \frac{W_1 - W_2}{\text{Weight of sample}} \times \frac{100}{1} \dots (3)$$

Where: Initial weight of dry Soxhlet flask = W<sub>1</sub>; Final weight of oven dried flask + oil/fat = W<sub>2</sub>

**Determination of Crude Protein**

The crude protein of the sample was estimated by micro-kjeldahl. Two grams of sample was digested with 5 grams of anhydrous sodium sulphate (Na<sub>2</sub>SO<sub>4</sub>) and concentrated with 25 mL H<sub>2</sub>SO<sub>4</sub> in a fume chamber until a clear solution was obtained. The digested sample was allowed to cool at room temperature and then transferred into 250 mL volumetric flask and made up to volume with distilled water. The distillation apparatus was set up and five milliliters of 2 % boric acid solution with few drops of methyl red indicator was introduced into a distillate collector (100 mL conical flask). The conical flask was placed under the condenser. Then 5 mL of the sample digested was pipetted into the apparatus, and washed down with distilled water. Five milliliters of 60 % NaOH solution was added to the digest. The sample was heated until 100 mL of distillate is collected in the receiving flask. The content of the receiving flask was titrated with 0.049 M H<sub>2</sub>SO<sub>4</sub> to a pink colour end point. A blank with filter paper was subjected to the same procedure.

crucible and dried at 100 °C overnight, cooled in the desiccator and weighed before incineration. The difference in weight between oven dried weight and

weight after incineration was taken as fibre content of the sample. This was expressed as a percentage weight of the original sample taken for analysis

$$\% \text{ Crude Fibre} = \frac{\text{Oven dried sample} \times \text{Weight of sample incineration}}{\text{Weight of sample taken}} \dots\dots (5)$$

### Determination of Carbohydrate Content (By Difference)

The carbohydrate content was calculated by difference following AOAC (2010). Total carbohydrate = 100 – (moisture + fat + fiber + ash + protein) %.

### Functional Properties of Flours

#### pH

The pH of the food samples was measured according to the method described by Onwuka (2005). A 10 g of blended homogenous sample was dissolved in 100 mL of de-ionized water, mixture was filtered and pH of the filtrate was measured using a pH meter.

#### Bulk density

The Bulk density of the blends was determined following the method (Olapade *et al.*, 2011). Ten (10) grams of flour sample was weighed into a 100 mL graduated cylinder. The cylinder was tapped continuously until a constant volume was obtained and the level was recorded. The bulk density was calculated as weight of flours (g) by the volume (cm<sup>3</sup>).

#### Water Absorption Capacity (WAC)

The procedure of Olapade *et al.* (2011) was used. Ten milliliters of water was added to 1.0 gram of each

$$\text{Swelling index} = \frac{\text{Volume occupied by sample after swelling}}{\text{Initial volume occupied by sample before swelling}} \dots\dots\dots (6)$$

#### Colour Evaluation of Flour Blends

The color of blend samples was determined using a Chroma-meter equipped with a D65 illuminant on the basis of CIE L\*, a\* and b\* system as described by (Kaur and Singh, 2005). L\* represented lightness (with 0= darkness/ blackness to 100= perfect/brightness); a\* corresponds to the extent of green colour (in the range from negative= green to positive = redness); b\* represents blue in the range from negative=blue to positive=yellow. The colorimeter was calibrated against a standard white reference tile. The L\*, a\* and b\* readings were obtained directly from the instrument and provided measures of lightness, redness and yellowness, respectively. All measurements were performed in triplicate and mean value recorded.

#### Statistical Analysis of Data

Experiments were replicated five times and the collected data were subjected to analysis of variance

blend samples, the suspension was stirred with the aid of magnetic stirrer for 5 minutes. The suspension was transferred into centrifuge tubes and centrifuged for 30 minutes at 3,500 rpm. The free water was poured in a cylinder and the volume was determined. Water absorption was calculated as the difference between the initial water and the volume of the free water obtained after centrifuging.

#### Oil Absorption Capacity (OAC)

Oil absorption capacity was determined following the method Onwuka (2005). One gram of sample was mixed with 10 mL of oil. The mixture was allowed to stand for 30 minutes at 25 °C and centrifuge at 3,500 rpm for 30 minutes. Oil absorption capacity was expressed as gram of oil bound per gram flour.

#### Swelling power

Swelling power of sample was determined by the method (Shahzadi *et al.*, 2005). One gram of the sample was measured into a 10 mL measuring cylinder. Then 5 mL of distilled water was added to the sample and allowed to stand for one hour. The final volume after swelling was recorded.

(ANOVA) using a completely randomized design. The difference between the means was separated by Duncan Multiple Range Test.

### Results And Discussion

#### Proximate Composition of African yam bean, Pearl millet and Tigernut flours

The proximate composition of the flours obtained from the processing of African yam bean (ORM), pearl millet (LFJ), and tigernut (CRQ) are shown in Table 2. The flour sample ORM possessed maximum protein (20.82 %) and ash (3.32 %), LFJ had highest in carbohydrate (70.00 %) and CRQ had highest moisture (12.63 %), fat (29.31 %) and fiber (9.87 %) contents. The protein content of flour samples varied with significant difference (p<0.05). The highest value of protein content in ORM can be attributed to the fact that legumes are generally rich in protein which is as twice as those found in cereals and several times in tubers (Shukla and Sivasanka, 2005). Values in protein content of ORM flour was justified by values (19 and

30 %) reported (Ade-omowaye *et al.*, 2015). Several authors have studied different variants of AYB and reported slight differences in protein content ranging from 22.23 to 25.78 % (Adeyeye *et al.*, 1994), 22.72 to 26.68 % (Ajibola and Olapade, 2016) and 21.84 to 23.41 % (Baiyeri *et al.*, 2018). Increased ash content in sample ORM indicates the presence of certain minerals relative to other flour samples. Previous study agreed with the result of ash content observed in this study (Ijarotimi and Bakare, 2006). The highest carbohydrate in LFJ is highly based on possession of large germ size in pearl millet (cereal) which apparently grouped them as energy-dense food (Saldivar, 2003). All values obtained in LFJ were justified with National Research Council (1996) reported on various types of pearl millet, ranking best Table 2: Proximate Composition of Raw Materials (%)

Sample	Moisture	Protein	Fat	Ash	Fiber	Carbohydrate
ORM	12.37±1.0.80 <sup>a</sup>	20.82±1.92 <sup>a</sup>	2.27±0.93 <sup>b</sup>	3.32±0.33 <sup>a</sup>	3.46±0.56 <sup>b</sup>	57.76±1.46 <sup>b</sup>
LFJ	10.74±0.22 <sup>b</sup>	10.93±1.03 <sup>b</sup>	3.71±1.17 <sup>b</sup>	2.25±0.05 <sup>a</sup>	2.36±0.05 <sup>b</sup>	70.00±1.78 <sup>a</sup>
CRQ	12.63±0.33 <sup>a</sup>	6.17±0.01 <sup>c</sup>	29.31±1.54 <sup>a</sup>	3.03±0.15 <sup>a</sup>	9.87±1.26 <sup>a</sup>	46.41±1.59 <sup>c</sup>

Values are means ±SD of triplicate determinations. SD= Standard deviation. Values in the same column with different superscripts were significantly different at 5 % probability level ( $p < 0.05$ ).

Remark: ORM: 100% African yam bean flour; LFJ: 100% Pearl millet flour; CRQ: 100% Tigernut flour

The values of moisture content of tigernut flour in this study was lower to 42.40 % (Suleiman *et al.*, 2018); African yam bean falls within 1.93 -13.30 % reported by (Abioye *et al.*, 2015) and pearl millet flour concurred with (Adebowale *et al.* 2015). Therefore, obtained values in this study are within the recommended moisture content for safety (14.50 %), although moisture content of a sample largely depends on postharvest drying, handling and storage conditions.

The highest fiber in flour sample CRQ makes them a potential source of important functional foods to consumers because fiber consumption lowers the incidence of lifestyle diseases among consumers (Awofadeju, 2020). Additionally, with the growing consumer awareness on the need to consume healthy foods tigernut can be a good source of inexpensive, yet health-benefiting food commodity to consumers across all socio-economic statutes. From preliminary study, Suleiman *et al.* (2015) recorded higher value (13.10 %) compared to result obtained in this study. In contrast, Temple *et al.* (1998) reported a lower fiber value (5.50 %). A 100 g of tigernut consumed would play an important role in the reduction of pressure and transit time of food through body aiding digestion (Temple *et al.*, 1998). Fiber aids in alleviation of flatulence problem, thus, tigernut fiber could be explored in formulating diets for treating indigestion, constipation and non-communicable diseases such as

among others based on lowest moisture (10 %) and carbohydrate (70 %); and highest protein (11.8 %) and ash (2.3 %) contents. The moisture content of flour is an important parameter, thus greatly influences the stability of any food product. There was no noticeable difference ( $p > 0.05$ ) between ORM and CRQ but differ significantly ( $p < 0.05$ ) from LFJ. Generally, cereal has low moisture content typically 10 to 15 % owing to their size (less than 1 g) and possession of hard texture (FAO, 1983), which enable natural stability and prolonged shelf life better than legume and tubers. According to Shahzadi *et al.* (2005) reported flour having less than 13 % moisture content and prolonged shelf life from moisture-dependent deterioration otherwise would be prone to mold and bacterial growth.

colon cancer, diverticulosis, coronary heart disease and obesity (Wardlaw and Kessel, 2002). The highest fat content was recorded for tigernut flour and are noted to contain as much as 35 % (Oladele and Aina, 2007), 17 % (Suleiman *et al.*, 2018) and 24 % (Basman and Koxsel, 2003), while most legumes such as African yam bean contain less than 3 % fat (Ihekoronye and Ngoddy, 1985). No significant ( $p < 0.05$ ) differences were observed between ORM and CRQ samples. The ORM is low in fat, and this is expected since it is classified as pulse. Pulse, unlike oil seeds, has very low fats usually less than 10 % but sometimes be slightly higher (Ade-omowaye *et al.*, 2015). Also, low fat content in AYB makes their handling, processing and storage easy (Abioye *et al.*, 2015). Differences in results obtained in this study and preliminary reports could be attributed to several factors including different planting location, agronomic practices as well as seasons of the year.

The Proximate Composition of African yam bean, Pearl millet and Tigernut Flour Blends

The proximate composition of flour blends obtained is presented (Table 3). There were significant ( $p < 0.05$ ) differences in all the measured parameters. The moisture content of the flour blends ranged between 10.56 to 12.18 %. Sample JLX was found to be highest in moisture content and STE appeared lowest. The ratio of African yam bean and pearl millet (70:20) flours contributed to high moisture content in the

blends as it was shown in the initial result presented in Table 1. This moisture content obtained was however below 14 % water content for shelf-stable storage and

viability of flour blends thus, useful for a shelf stable product (Chakraverty, 2004). Hence, there will be mold and bacterial growth if above 14.5 %.

Table 3: The Proximate Composition of Varied Ratio of African Yam Bean, Pearl Millet and Tigernut Flour Blends

Sample	Moisture	Protein	Fat	Ash	Fibre	CHO	Total energy
RPA	11.44±0.60 <sup>b</sup>	16.12±0.11 <sup>a</sup>	10.50±0.50 <sup>a</sup>	3.03±0.15 <sup>a</sup>	2.71±0.19 <sup>b</sup>	56.19±0.26 <sup>c</sup>	383.74±3.27 <sup>a</sup>
STE	10.56±0.38 <sup>c</sup>	15.57±0.08 <sup>b</sup>	9.53±0.93 <sup>ab</sup>	2.70±0.44 <sup>ab</sup>	3.19±0.21 <sup>a</sup>	58.45±0.96 <sup>ab</sup>	381.88±5.47 <sup>a</sup>
JLX	12.18±0.20 <sup>a</sup>	15.17±0.23 <sup>c</sup>	10.10±0.26 <sup>a</sup>	2.37±0.15 <sup>b</sup>	2.87±0.16 <sup>ab</sup>	57.52±0.45 <sup>ab</sup>	381.65±1.26 <sup>a</sup>
MPO	11.63±0.76 <sup>a</sup>	14.67±0.06 <sup>d</sup>	8.47±1.00 <sup>b</sup>	2.03±0.25 <sup>ab</sup>	2.43±0.25 <sup>a</sup>	59.61±1.13 <sup>a</sup>	373.35±5.04 <sup>b</sup>

Values are means ±S.D of duplicate determinations. \* SD= Standard deviation. Values in the same row with different superscripts were significantly different at 5% probability level ( $p < 0.05$ ). Remark: RPA- 80% African yam bean flour, 10% pearl millet flour and 10% tigernut flour; STE:70%African yam bean flour, 20% pearl millet flour and 10% tigernut flour; JLX: 60%African yam bean flour, 30% pearl millet flour and 10% tigernut flour; MPO: 50% African yam bean flour, 40% pearl millet flour and 10% tigernut flour

The protein content of the flour blends decreased with increasing substitution levels of pearl millet flour. The value ranges from 14.67 to 16.12 %. Significant ( $p < 0.05$ ) differences were observed among the samples. The protein content was highest in sample RPA while lowest was observed in sample MPO. The highest protein content recorded was probably due to high amount of protein associated with legume which form basic amount of the flour. This result is similar to value reported by Adelekan *et al.* (2012) for use of African yam beans and shrimps in the production of maize-based cereal blends. Hence, protein is an important component that determines the rheological properties of composite flours.

The fat content of the flour blends varied significantly and were relatively high in all the flour samples. The fat content ranged between 8.47 to 10.50 %. The optimum value was recorded in sample RPA while minimum content was found in sample MPO. The high fat might be due to fat content in tigernut which reflected in the flour (Table 1) and the statement was justified by Basman and Koksel (2003) reported 24 to 30 %. Result achieved in this study agreed with ranged values 1.3 to 11.0 % reported by Adebayo-Oyetoro *et al.* (2017) for production and acceptability of *chinchin* snack made from wheat and tigernut flour. However, de-fatting the tigernut before utilization may yield better result. The ash content (%) of the composite flour significantly ( $p < 0.05$ ) decreased from 3.03 to 2.03 with increasing inclusion of pearl millet flour. This may be attributed to low ash content of pearl millet as shown in raw material flour (Table 2). Ash content is a reflection of mineral status in a sample. Nevertheless, the values were higher than 1.34-2.58 % for banana-wheat composite cake (Eke *et al.*, 2007). More so, trend in results obtained in this work was in agreement with rice-based composite flour (Awolu *et al.*, 2017).

Fibre is important in the diet for enhancing bowel movement, preventing overweight, constipation and reducing the risk of colon cancer (Anderson *et al.*, 2009; Ayinde *et al.*, 2012). The fibre content of the flour blends ranges from 2.27 to 3.19 %. Significant ( $p < 0.05$ ) differences were observed among the samples. The fibre content was highest in sample STE while lowest value was observed in sample MPO. Tigernut had substantial highest crude fibre than African yam bean and pearl millet (Table 2), and this justify the high amount of fibre obtained in blends. In addition, Ibeogu (2020) concur with the statement in production of weaning food from mung bean, pearl millet and tigernut, and Ade-Omowaye *et al.* (2008) observed increased in value as tigernut substitution increases in the formulation of wheat-tigernut based bread. Carbohydrate content of the composite flour varied significantly ( $p < 0.05$ ) and ranged from 56.19 to 59.61 %. Sample MPO had highest carbohydrate while lowest was found in RPO. The values observed in sample MPO was attributed to highest carbohydrate content in pearl millet flour (Table 1). In addition, all the flour blends suggested a very good source of energy. However, Ibeogu (2020) concur with the statement and reported the high values in weaning food due to increase in pearl millet inclusion and Ade-Omowaye *et al.* (2008) reported decrease in values owing to increase in tigernut substitution in wheat-tigernut based bread. The energy value of the flour blend decreased from 383.74 to 373.35 kcal/100g. The decreasing substitution level of African yam bean in the blends decreased the total energy. The results obtained are in ranged with values reported by Kent (1983) for treated ready-to-eat breakfast cereal foods of energy value between 314.0-420.0 Kcal/100g. The high energy content is advantageous for product formulation like breakfast cereals as observed in sample RPA.

### Colour Evaluation of Flour Blends

Colour evaluation is an important part of safety, marketability in the food industry and also affects crumb color of finished products. Numerous studies have shown that visual acceptance is the first thing consumers rely on when making choices in food (Mares and Campbell, 2001). Food color is so influential, it can even change the way consumers perceive taste and quality in foods and provides some indication of quality in the starting materials (Mares and Campbell, 2001). The colour composition of flour blends obtained from varying ratio of African yam bean, pearl millet and tigernut flour blends are presented in Table 4. There were significant ( $p < 0.05$ ) differences in all the measured parameters. The  $L^*$  and  $b^*$  values are the most important in flour. It is highly

desirable for refined flours to have a bright white color (high  $L^*$ ). However, the results indicated that degree of lightness ( $L^*$ ) and yellowness ( $b^*$ ) decreased from 69.65 to 50.15 and 18.45 to 12.27 as the amount of pearl millet flour increases leading to dark appearance of the flour blends. Apparently, a very strong light  $L^*$  and yellow  $b^*$  color is desirable as yellowness is caused by natural pigments in the tigernut flour. Furthermore, redness of the blends ( $a^*$ ) decreased substantially as the decrease in flour color could be attributed to inclusion of pearl millet. This suggests that substitution of pearl millet in composite flour should not exceed 30%. A typical straight grade flour has an  $L^*$  value of 92.5, yellow tint with  $b^*$  of +6.9 and  $a^*$  value of -2.5 which tends towards greenish or reddish.

Table 4 Colour evaluation of flour blends

SAMPLES	$L^*$	$a^*$	$b^*$
RPA	69.65±2.97 <sup>b</sup>	8.10±0.32 <sup>b</sup>	18.45±1.00 <sup>b</sup>
STE	68.33±0.62 <sup>c</sup>	9.60±0.09 <sup>d</sup>	17.98±0.18 <sup>a</sup>
JLX	66.14±0.27 <sup>c</sup>	9.00±0.03 <sup>c</sup>	17.65±0.07 <sup>a</sup>
MPO	50.15±0.01 <sup>a</sup>	-7.12±0.0 <sup>a</sup>	12.27±0.01 <sup>c</sup>

Values are means ±S.D of triplicate determinations. \* SD= Standard deviation. Values in the same column with different superscripts were significantly different at 5% probability level ( $p < 0.05$ ).

Remark: RPA-80% African yam bean flour, 10% pearl millet flour and 10% tigernut flour, STE-70% African yam bean flour, 20% pearl millet flour and 10% tigernut flour, JLX- 60% African yam bean flour, 30% pearl millet flour and 10% tigernut flour, MPO-50% African yam bean flour, 40% pearl millet flour and 10% tigernut flour

### Functional Properties of Flour Blends

Functional properties are characteristics of a substance added during processing thereby affecting food behavior and products (IFIS, 2005) (Table 6). The pH is the degree of acidity or alkalinity. The pH and loosed bulk density of flour samples RPA had highest while JLX and MPO shared same values. Tapped bulk density (TBD), WAC, OAC and swelling capacity of

the blends were highest in sample MPO. With the exception of TBD, lowest values occurred in sample RPA for WAC, OAC and swelling capacity. Apparently values in OAC, WAC and swelling capacity increased as African yam bean flour decreases with increasing substitution level of pearl millet flour and the statement negate sample LBD.

Table 5: Functional properties of varied ratio of African yam bean, pearl millet and tigernut flour blends.

Samples	RPA	STE	JLX	MPO
pH	6.23±0.015 <sup>a</sup>	6.10±0.02 <sup>a</sup>	6.20±0.02 <sup>a</sup>	6.20±0.10 <sup>a</sup>
LBD (g/ml)	0.47±0.01 <sup>a</sup>	0.44±0.02 <sup>b</sup>	0.43±0.01 <sup>b</sup>	0.43±0.02 <sup>b</sup>
TBD (g/ml)	0.67±0.02 <sup>a</sup>	0.66±0.01 <sup>ab</sup>	0.64±0.02 <sup>b</sup>	0.68±0.02 <sup>b</sup>
WAC(g/g)	1.50±0.20 <sup>b</sup>	1.93±0.05 <sup>a</sup>	2.00±0.10 <sup>a</sup>	2.03±0.15 <sup>a</sup>
OAC(g/g)	2.53±0.15 <sup>a</sup>	2.53±0.15 <sup>a</sup>	2.60±0.10 <sup>a</sup>	2.70±0.10 <sup>a</sup>
Swelling capacity	1.27±0.01 <sup>c</sup>	1.36±0.03 <sup>b</sup>	1.48±0.02 <sup>a</sup>	1.55±0.02 <sup>a</sup>

Values are means ±SD of duplicate determinations. \* SD= Standard deviation.

Values in the same row with different superscripts were significantly different at 5% probability level ( $p < 0.05$ ).

Key: RPA: 80% African yam bean flour, 10% pearl millet flour and 10% tigernut flour

STE: 70% African yam bean flour, 20% pearl millet flour and 10% tigernut flour; JLX: 60% African yam bean flour, 30% pearl millet flour and 10% tigernut flour; MPO: 50% African yam bean flour, 40% pearl millet flour and 10% tigernut flour; LBD = Loosed Bulk Density, PBD = Packed Bulk Density, OAC = Oil Absorption Capacity  
WAC = Water Absorption Capacity

There were no significant differences ( $p < 0.05$ ) in the pH and OAC of the flour blends. All the pH values were within the acidic range. This report agreed with those of Onuoha and Obizoba (2001) who reported that digestibility of fermented lima bean was facilitated by the acidic range. Bulk density gives information on the porosity of a product influencing the choice of packaging materials and its design (Odedeji and Oyeleke, 2011). Both loosed bulk density (LBD) and tapped bulk density (TBD) of the flours varied significantly. There were significant differences ( $p < 0.05$ ) in bulk density, WAC and swelling capacity of the blends. According to Plaami (1997) reported that bulk density is influenced by the structure of the starch polymers and loose structure of the starch polymers could result in low bulk density. It was observed that the composite flour blends are heavy which implies that a solid, thick and compact packaging material may be required (Osundahunsi and Aworh, 2002). The blends absorb water as level of African yam bean flour decreases with increasing substitution level of pearl millet flour. This may be attributed to the high carbohydrate and fiber contents in pearl millet and tiger nut flours, as carbohydrate and fiber was reported to greatly influence the water absorption capacity of foods (Anthony *et al.*, 2014). From the results, the entire composite blends showed favorable water absorption capacity thus making them suitable raw material or functional ingredients in the development of ready-to-eat products. High water absorption capacity often assures product cohesiveness (Kulkarni *et al.*, 1996) therefore, water binding capacities is an important functional characteristic in development of ready-to-eat products. Oil absorption capacity of flours is important for the development of new food products influencing storage stability (Falade and Olugbuyi, 2010). The results showed that the flour blends had relatively high oil absorption capacity as a result of hydrophobic character of protein in the African yam bean plus high content of oil in tigernut flours (Ade-Omowaye *et al.*, (2008). The presence of protein exposes more non-polar amino acids to the fat and enhances hydrophobicity as a result of flour absorbing more oil (Oluwalana *et al.*, 2011). The swelling power increased as the ratio of African yam bean decreased. The swelling power is an indication of amylase which influences the quantity of amylose and amylopectin in a sample, hence presence of amylose and amylopectin in African yam bean. Therefore, the higher the

swelling power, the higher the associate forces (Ruales *et al.*, 1993).

### Conclusion

The suitability of composite flours from underutilized crops in baking applications depends on the understanding of their functional and physicochemical properties. However, this study shows that composite blends of African yam bean, pearl millet and tigernut flours enhanced physicochemical and functional properties in the blends as well as complementing each other. Therefore, the best formulation was observed in ratio 80:10:10 which could add value to Nigerian food industry in bakery application thereby reducing wheat importation, creating more hands in farming system and increased Nigerian economy. Also, reduce malnutrition in consumers especially in children.

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### References

- Abioye, V., Olanipekun, B. and Omotosho, O. (2015). Effect of varieties on the proximate, nutritional and anti-nutritional composition of nine variants of African yam bean seeds (*Sphenostylis stenocarpa*). *Donnish J. Food Sci. Technol.* 1, 17–21.
- Adebayo-Oyetoro A. O., Ogundipe O. O., Lofinmakin F. A., Akinwande F. F., Aina D. O. and Adeyeye S. A. O (2017). Production and acceptability of *chinchin* snack made from wheat and tigernut (*Cyperus esculentus*) flour. Vol 3 (1) *Cogent Food Agri*. Doi.org/10.1080/23311932.2017.1282185
- Adebowale A. A., Fetuga G. O., Apata C. B. and Sanni L. O. (2015). Effect of variety and initial moisture content on physical properties of improved pearl millet grains. *Nig. Food J.* vol 30(1): pp 5-10. [https://doi.org/10.1016/S0189-7241\(15\)3007-2](https://doi.org/10.1016/S0189-7241(15)3007-2)
- Adelekan, A. O., Arisa, N.U. and Laguda, O.O. (2012) The Use of African Yam Beans and Shrimps in the Production of Maize-Based Cereal Blends. *J. Nutr. Food Sci.* 2:155
- Ade-Omowaye B. I. O., Akinwande B. A., Bolarinwa I. F. and Adebisi A. O. (2008). Evaluation of tigernut (*Cyperus esculentus*)-wheat composite flour and

bread. *Afri. J. Food Sci.* vol (2) pp. 087-091. Available online <http://www.acadeicjournals.org/ajfs>

Adeyeye, E.I., Oshodi, A.A., Ipinmoroti, K.O., 1994. Functional properties of some varieties of African yam bean (*Sphenostylis stenocarpa*) flour II. *Int. J. Food Sci. Nutr.* 45, 115–126.

Ajibola, G.O. and Olapade, A.A., (2016). Physical, proximate and anti-nutritional composition of African yam bean (*Sphenostylis stenocarpa*) seeds varieties. *J. Food Res.* 5, 67.

Alobo A. P. and Ogbogo P. O (2007). Selected properties of tigernut starch as affected by physical and chemical modifications. Proceeding of the 31st annual NIFST conference, Abuja, Nigeria. 22nd – 25th October, 2007.

Anderson, J.W., Baird, P. and Richard, H. (2009). Health Benefits of Dietary Fibre Nutrition Review, 67(4):188-205.

Aniedu, C. and Aniedu, O.C. (2014). Fortification of Cassava fufu flour with African yam bean flour: implications for improved nutrition in Nigeria. *Pelagia Res. Libr. Asian J. Plant Sci. Res.* 4, 63–66.

Anthony, N. M., Sawi, M. K., Aiyelaagbe, O. O., Taiwo, A., Winnebah, T. and Fomba, S. N. (2014). Proximate characteristics and complementary assessment of five organic sweet potatoes cultivars and cowpea varieties. *Int. J. Eng. Sci.:* vol 3(9):38–42.

Awofadeju, O. F. J. (2020). Evaluation of Protein Quality in Blends Prepared from Commercial Wheat (*Triticum aestivum*) and Yellow Maize Flours (*Zea mays*) and African Walnut (*Tetracarpidium conophorum*) Protein Isolate. *Euro Mod Stud J.* 4(1): ISSN 2522-9400

Anya, M.I. and Ozung, P.O. (2019). Proximate, mineral and anti-nutritional compositions of raw and processed African Yambean (*Sphenostylis stenocarpa*) seeds in Cross River State, Nigeria. *Global J. Agric. Sci.* 18, 19.

AOAC (2010). Official Methods of Analysis, 18th Ed. Association of Official Analytical Chemists, Washington D.C, USA.

Awolu OO, Olarewaju OA, Akinade A.( 2017). Effect of the addition of pearl millet flour subjected to different processing on the antioxidants, nutritional, pasting characteristics and cookies quality of rice-based composite flour. *J Nutr Health Food Eng.;*7(2):247–256. DOI: 10.15406/jnhfe2017.07.00 232

Ayinde, F.A., Bolaji, O.T, Abdus-Salaam, R.B and Osidipe, O. (2012). Functional properties and quality evaluation of kokoro blended with beni seed cake and *Sesame indicum*. *Afr. J. Food Sci.* 6(5):117-123.

Babarinde, G., Adeyanju, J. and Omogunsoye, A. (2019). Protein enriched breakfast meal from sweet potato and African yam bean mixes. *Bang. J. Sci. Ind. Res.* 54, 125–130

Baiyeri, S., Uguru, M., Ogbonna, P., Samuel-Baiyeri, C.C., Okechukwu, R., Kumaga, F. and Amoatey, C. 2018. Evaluation of the nutritional composition of the seeds of some selected African yam bean (*Sphenostylis stenocarpa*). *Agro-Sci. J. Trop. Agric. Food Environ. Ext.* 17, 37–44.

Basman, A. and Koksel, H. (2003). Utilization of Trans glutaminase to increase the level of barley and soy flour incorporation in wheat flour breads. *J. Food Sci.* 68, 2453–2460.

Chakraverty, A. (2004). Post harvest of oil seeds. New Delhi: Oxford Publishing Company, Private Limited; p. 339.

Chevallier A (1996). The Encyclopedia of medicinal plants. Dorling Kindersley. London. ISBN. 9: 980751-303148.

Dendy, D. A. V. (1992). Composite flour- past, present and the future: a review with special emphasis on the place of composite flour in the semi-arid zones. In M.I. Gomez, L. R. House, L. W. Rooney and D. A. V. Dendy, eds. Utilization of songhumand millets, p. 67-73. Patancheru, Inde, ICRISAT

Devi, P. B., R. Vijayabharathi, S. Sathyabama, N. G. Malleshi and V. B. Priyadarisini. 2011. Health benefits of finger pearl millet (*Eleusine coracana* L.) polyphenols and dietary fiber: A review. *J. Food Sci. Technol.* DOI: 10.1007/s13197-011-0584-9

Duodu, K.G. and Apea-Bah, F.B. (2017). African Legumes: Nutritional and Health-Promoting Attributes. *Gluten-free Ancient Grains: Cereals, Pseudocereals, and Legumes: Sustainable, Nutritious, and Health-Promoting Foods for the 21st Century.* Elsevier Ltd.

Eke, J., Sanni, S.A. and Owuno, F. (2007). Proximate and sensory properties of banana cakes. *Nigeria Food Journal*, 27(2):102-106.

Enwere, J.N. (1998). Foods of Plant Origin: Processing and Utilization with Recipes and Technology Profiles. *1st Eds. Afro-orbis Publications Ltd*, pp: 50-60.

Eromosele, C.O., Arogundade, L.A., Eromosele, I.C and Ademuyiwa O. (2008). Extractability of African yam bean (*Stenophylis stenocarpa*) protein acid, salt and alkaline aqueous media. *Food Hydrocolloids*, 22: 1622-1628

Falade, K. O and A. O. Olugbuyi, (2010): Effects of Maturity and Drying Methods on the Physico chemical

and reconstitution properties of plantain flour. *Int. J. Food Sci. Technol.* 45:170-178.

FAO. 2009. FAOSTAT. Food and Agriculture Organisation of the United Nations. FAOSTAT. <http://faostat.fao.org/site/339/default.aspx>

Gélinas, P., C. M. McKinnon, M. C. Mena and E. Méndez. 2008. Gluten contamination of cereal foods in Canada. *Int. J. Food Sci. Technol.* 43(7):1245–1252.

Ibeogu, I. H (2020). Production and evaluation of weaning food made from mungbean (*Vignaradiata* (L.), pearl millet and tigernut (*Cyperus esculentus*) flour blends. *Int. J. Res. Scientific Innov.* (IJRSI) vol 7(7) pp 16-20 ISSN 2321-2705

Idowu, A. (2014). Development, nutrient composition and sensory properties of biscuits produced from composite flour of wheat and African yam bean. *Br. J. Appl. Sci. Technol.* 4, 1925–1933.

Idowu, A. (2015a). Chemical composition and sensory and pasting properties of blends of maize-African yam bean seed. *J. Nutr. Health Food Sci.* 3, 1–6.

Idowu, A.O. (2015b). Nutrient composition and sensory properties of kokoro (Nigerian snack) made from maize and African yam bean flour blends. *Int. Food Res. J.* 22, 739–744

IFIS, (2005). Dictionary of Food Science and Technology. International Food Information Service. Blackwell Publishing, Oxford (U.K.), 157-284.

Igbabul, B., Num, G. and Amove, J. (2014). Quality Evaluation of Composite Bread Produced from Wheat, Maize and Orange Fleshed Sweet Potato Flours. *Ame. J. Food Sci. Technol.* vol. 2(4): 109-115.

Ihekoronye, A.I. and Ngoddy, P.O. (1985). Integrated Food Science and Technology for the Tropics, Macmillian Publishers Limited, London, 236-253.

Ijarotimi, S.O. and Bakere, S.S. (2006). Evaluation of proximate, mineral and antinutritional factor of home processed complementary diet from locally available food materials (sorghum bicolor and *Sphenostylis stenocarpa*). *J. Food Technol.* 4, 339–344.

Iwe, M.O., Onyeukwu, U. and Agiriga, A.N. (2016). Proximate, functional and pasting properties of FARO 44 rice, African yam bean and brown cowpea seeds composite flour. *Cogent Food Agric.* 2.

Jideani, I. A. and Osume, B. U. (2001). Comparative studies on the Microbiology Of three Nigerian fermented beverages - Burukutu, Pito and Nbal. *Nig. Food J.* 19: 136 – 144.

Kaur M and Singh N. (2005). Studies on functional thermal and pasting properties of flours from different

chickpea (*Cicer arietinum* L.) cultivars. *Food Chemistry.* 91(3):403–411.

Kent, N. L. (1983). Technology of cereals, Pergamon Press, Oxford, pp.139 - 142.

Kulkarni, K.D., Noel, G. and Kulkarni, D.N. (1996). Sorghum malt-based weaning food formulations: preparation, functional properties and nutritive value. *Food Nutr. Bulletin*, 13(4):322-327.

Mares, D.J. and Campbell, A.W. (2001). Mapping components of flour and noodle color in Australian wheat. *Australia J. Agric. Res.* 52:1297-1309.

Ndidi, U.S., Ndidi, C.U., Olagunju, A., Muhammad, A., Billy, F.G. and Okpe, O. (2014). Proximate, anti-nutrients and mineral composition of raw and processed (boiled and roasted) *Sphenostylis stenocarpa* seeds from Southern Kaduna, Northwest Nigeria ISRN Nutr. 1–9

Nwosu, J.N. (2013). Evaluation of the proximate composition and anti-nutritional properties of African yam bean (*Sphenostylis stenocarpa*) using malting treatment. *Int. J. Basic Appl. Sci.* 2, 157–169.

Obilana, A. B. and E. Manyasa (2002). Pearl millets In: P. S. Belton and J. R. N. Taylor (Eds.). pp. 177–217. Pseudo cereals and less common cereals: Grain properties and utilization potential. Springer-Verlag: New York.

Odedeji J. O. and Oyeleke W. A. (2011). Proximate, physicochemical and organoleptic properties of whole and dehulled cowpea seed flour (*Vigna unguiculata*). *Pak. J. Nutr.* 10(12): 1175-1178

Odunfa, S.A. and Adeyele, S. (1985). Microbiological changes during the traditional production of Ogi-baba, A West African fermented sorghum gruel. *J Cereal Science* 3: 173-180.

Oladele AK, K Aina JO (2007). Chemical composition and functional properties of flour from two varieties of tigernut (*Cyperus esculentus*) *Afr. J. Biotechnol.* 6(21): 2473-2476.

Olapade, A.A., Ugokwe P.U., Ozumba A.U., Solomon H.M., Olatunji O. and Adelaja S.O (2004). Physico-chemical properties of premixes for the preparation of akara. *Nig. food J.* 2(2):54-59.

Oluwalana, I.B., Oluwamukomi, M.O., Fagbemi, T.N. and Oluwafemi, G.I. (2011). Effects of temperature and period of blanching on the pasting and functional properties of plantain (*Musa parasidiaca*) flour. *J. Stored Prod. Postharvest Res.* 2:164-169.

Onuoha N. and Obizoba I. C. (2001). Improvement of the nutritional value of lima beans by the process of fermentation. *Nig. J. Biochem.* 16(1):46-49

Onwuka, G.I. (2005). Food Analysis and Instrumentation: Theory and Practice. Naphthali Prints, Lagos. Nigeria

Osundahunsi, O. F. and Aworh, O. C. (2002): A preliminary study on use of tempe-based formula as weaning diet in Nigeria. *J. Food Hum. Nutr.* 57, 365-376.

Plaami, S.P. (1997). Content of dietary Fiber in Foods and its physiological effects. *Food Rev. Int.* 13:27-76.

Ruales, J. and Nair, B.M. (1993).Content of fat, vitamins and minerals in quinoa (*Chenopodium quinoa Willd*) seeds. *Food Chemistry*, 48:131-136.

Saldivar, S. (2003). Cereals: dietary importance. In: B. Caballero, L. Trugo and P. Finglas (Eds.). pp. 1027–1033. *Encyclopedia of Food Sciences and Nutrition*, Reino Unido: Academic Press, Agosto, London.

Shahzadi, N., Butt, M.S., Rehman, S.U. and Sharif, K. (2005).Chemical characteristics of various composite flours. *Int. J. Agri. Biology*, 7:105-108.

Shukla, K. and Srivastava S. (2011). Evaluation of finger pearl millet incorporated noodles for nutritive value and glycemic index. *J. Food Sci. Technol.* DOI: 10.1007/s13197-011-0530-x

Suleiman M. S., Olajide J. E., Omale J. A., Abbah O. C. and Ejembi D. O. (2018). Proximate composition, minerals and some vitamin contents of tiger nut (*Cyperus esculentus*). *Clin. Invest. (London)* 8(4): 161-165

Temple VJ, Ojobe TO and Kapu MM. Chemical analysis of tigernut (*Cyperus esculentus*). *J Sci Agric* 50: 261-263 (1998).

USDA (2012). U.S. Department of Agriculture, Agricultural Research Service. 2012. USDA National Nutrient Database for Standard Reference, Release 25. Nutrient Data Laboratory Home Page, <http://www.ars.usda.gov/ba/bhnrc/ndl>

Waniska R. P., Venkatesha R. T., Chandrashekar A., Krishnaveni S., Bejosano F. P., Jeoung J. M., Jayaraman J., Muthukrishnan S. and Liang G. H. (2002). Antifungal proteins and other mechanisms in the control of sorghum stalk rot and grain mould. P. 287-297. In: J. F. Leslie, (ed.). *Sorghum and pearl millets diseases* 1st edn. Iowa State Press, Iowa.

Wardlaw G.M. and Kessel W.M. (2002). Calcium in Food Perspective in Nutrition (5th ed.) 410-411