



Full Length Research Paper

Physicochemical and sensory properties of blends from beniseed, trifoliate yam and wheat flours

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ABSTRACT

Composite flour blends of; wheat flour, beniseed flour and trifoliate yam of ratios; 90:5:5(WBT1), 70:15:15 (WBT2) and 50:25:25 (WBT3) respectively were utilized in the production of biscuits; WBTB1, WBTB2, WBTB3 respectively. Increase in beniseed and trifoliate yam substitution ensued improvements in; protein (0.78% and 3.49%, respectively), fat (5.47% and 2.79%, respectively), ash (0.89% and 0.80% respectively), and crude fibre (2.27% and 1.30% respectively) and decline ($P < 0.05$) in; moisture (2.29% and 1.67%, respectively) and carbohydrate (7.08% and 6.24%, respectively) of both composite flours and biscuits. Magnesium (0.27%), manganese (0.07%), sodium (0.14%), Calcium (0.38%), Iron (0.09%) and copper (0.15%) contents of the composite flours were boosted with increase in beniseed and trifoliate yam. WBT1 had the superior; bulk density, water absorption capacity and swelling capacity (0.66g/ml, 149.92% and 6.85ml., respectively). WBTB1 was the most sensory accepted. This study further indicates the suitability of cereal-tuber based flours for the baking industry.

Keywords: Wheat, Beniseed, Trifoliate yam, Composite flour, Biscuit

INTRODUCTION

Beniseed also known as "Sesame" (*Sesame indicum*) is an oil seed predominantly grown in northern and central Nigeria (Abou-Garbia et al. 2000). It is valued throughout history for its contribution as a food additive, in human nutrition (rich in edible oil (44-58%), protein (18 -25%), carbohydrate (13.5%) and ash (5%)) and its therapeutic prowess in disease prevention and promoting well-being (Morris, 2002; Uaboi-Egbenni et al. 2008; USDA, 2009). Beniseeds are highly valued for their oil which is remarkably resistant to rancidity (Weiss, 2000). The oil has a natural antioxidant which prevents aging and vital for the production of liver cells (Njoku et al. 2009). It contains better quality protein than most legumes and highly rich in; vitamin E, calcium, potassium, phosphorus, vitamin B, iron and contains no cholesterol (Dawodu, 2009; Adeniyani et al. 2013).

Also, its protein has a desirable amino acid profile and good nutritional value similar to soybean and better off compared to most legumes (Mohammed and Hamza 2008). Most especially it contains a considerably high methionine content which is limiting in most legumes (Osidiye, 2012). However, raw beniseeds contain oxalate

and phytate which are substances that prevent the accessibility of minerals (anti-nutritional factors) in the human system (Akanji, 2003).

Yam is a tuber that belongs to the genus *Dioscorea*. Of the estimated 300-600 species available, there are just over half-dozen species grown for consumption while others are grown for medicinal purposes. West Africa is the principal producer of yam on a global scale with the most common grown species namely; white yam (*Dioscorea rotundata*), water yam (*Dioscorea alata*), Chinese yam (*Dioscorea esculenta*) and trifoliate yam (*Dioscorea domentorum*) (FAO, 2003). Yams are valued for their high carbohydrate content alongside its root and tuber counterparts (cassava, potato, sweetpotato and taro). Trifoliate yam is a species upon which limited work has been done in terms of production and utilization though it is high yielding compared to other yams. It is not widely used because of the inferior quality of the tubers, bitter taste and poor binding capacity of its flours (Martin and Degras 1978; Ogbuagu, 2008). The tubers occur in clusters and have yellow edible flesh. The tubers are highly bitter especially the wild ones, however, some

cultivars have only slight bitter taste and cook faster than others (Sefa-Dedeh and Afoakwa 2001). It grows readily on various soils, the yield being 3-7 times that of other widely grown yam species (Treche and Guion 1979). The Trifoliate yam has been neglected in attempts to process roots and tubers into more durable and value added form. This is because of the severe hardening that develops post-harvest due to bruising and makes the tuber difficult to cook. Processing the tubers into a shelf stable product offers an alternative to fresh storage (Abiodun and Akinoso 2015).

The looming economic need by African countries in harnessing the high carbohydrate qualities of their indigenous root and tuber crops has facilitated their use in conjunction with wheat in several composite flours which have been utilized in an array of food products (Himeda et al. 2014; Chandra et al. 2015). Replete studies have investigated the utilization of both Trifoliate yam and beniseed flours as part of composite flour blends with cassava and wheat flour or both in the production of snacks, confectionaries, pastries and bread which provided remarkable outcomes (Abiodun et al. 2010; Ezeocha et al. 2011; Eke-Ejiofo and Owuno, 2012; Emmanuel-Ikpeme et al. 2012). However, there has not been any reported investigation of the utilisation of composite flour mix of wheat, beniseed and trifoliate yam. Therefore, this paper presents hereby another composite flour from underutilized flours which is aimed at providing an improved viable option for Wheat flour due to its overreliance by the baking industry.

MATERIALS AND METHODS

MATERIALS

Fresh trifoliate yam and beniseeds were obtained from Oyingbo market in Lagos state Nigeria. Whole wheat flour (Honeywell), whole milk powder (Peak), fat (Topper) and granulated sugar (Dangote) were sourced from a credible retail store (Justrite stores, Lagos). All reagents used were all of analytical grade and were sourced from accredited suppliers. Other materials used in this study were derived from credible sources.

Production of Beniseed flour

The beniseeds after purchase were sorted to remove contaminants, weighed and steeped in water at 25°C for 17-18 h to ease the dehulling process. The seeds were dehulled by sedimentation washing, dried at 40°C using a convection oven for 24h and then roasted at 110°C for 30min. The roasted beniseeds were milled using an attrition mill, then passed through a 100-mesh sieve and packaged in air tight containers.

Production of trifoliate yam flour

The tubers were; washed, peeled, sliced (0.5cm slices), boiled for 30minutes and dried in convection oven at 60°C for 48h. The dried samples were milled using a hammer mill and sieved through a 100-mesh sieve.

Blend formulation

Three composite flour blends were formulated based on percentage proportions of wheat flour, beniseed flour and trifoliate yam flour in the ratio; 5:5:90 (WBT1), 15:15:70 (WBT2) and 25:25:50 (WBT3) respectively using a machine food mixer (Kenwood M907 D England). Whole wheat flour (WWF) was used as control.

Biscuit formulation and production

The biscuit formulation is presented in Table 1. Sugar and fat were mixed until fluffy in a horizontal spindle mixer. Egg and whole milk were added and mixing was continued for 40 minutes. Composite flour, baking powder, vanilla flavour and salt were slowly introduced into the mixture and mixed until dough formation. The dough obtained were kneaded to a uniform thickness of 0.4 cm. Biscuit doughs were cut (4 cm), embossed, baked (at 160°C for 15 minutes), cooled and stored for analysis.

Chemical composition

The moisture content of the samples was determined using the procedure described by AOAC (2004). The protein (Kjeldahl), fat (Soxhlet), crude fibre and ash were determined by the methods described by AOAC (1990) methods. Carbohydrate was determined by difference (100 - Moisture + Ash + Crude protein + Fat contents). Magnesium, Calcium, Sodium, Manganese, Iron, Zinc, and Copper were determined by methods described by AOAC (1990). Phosphorous was determined by method described by Ceirwyn (1998).

The ash obtained from each sample was digested with 5ml of 2M hydrochloric acid and heated to dryness on a heating mantle. 2M Hydrochloric acid (5ml) was added to the ash and brought to boiling. This was filtered and 10ml of filtrate solution was pipetted into 50ml volumetric flask and 10ml of Vanadate-molybdate yellow added and the flask was made up to mark with distilled water, stopped and left for 10minutes for full yellow development. The spectrometric absorbance was taken.

Water absorption capacity

The water absorption capacity (WAC) were determined by the method of Sosulski et al. (1986). 1g sample was

Table 1. Recipe for biscuit

Ingredients	Weight (g)
Flour	200
Sugar	50
Fat	100
Baking powder	2.0
Salt	0.20
Egg	One whole egg
Vanilla flavour	0.20
Milk	3 tablespoonful

Source: Nwabueze & Atuonwu, (2007)

mixed with 10 ml of distilled water, kept at ambient temperature for 30 min and centrifuged for 10 min at 2000xg. WAC was expressed as percent water or oil bound per gram of the sample.

Bulk density

The bulk density (BD) was determined according to the method described by Igbagul et al. (2013). 5 g of sample and 50ml of deionised water were introduced into a 100 ml graduated cylinder. The bottom of the cylinder was tapped until there was no observable decrease in the volume of the sample. The BD was expressed as follows;

$$\text{Bulk Density} = \frac{\text{Weight of sample (g)}}{\text{Volume of sample (ml)}}$$

Swelling capacity

The method of Okaka and Potter (1977) with some modifications was used for determining the swelling capacity (SC). The 1g of sample was added to 10 deionized water in a 100 ml graduated cylinder with water added to adjust the total volume to 50 ml. The top of the graduated cylinder was tightly covered and mixed by inverting the cylinder. The suspension was inverted again after 2 min and allowed to stand for further 30 min. The volume (in ml) occupied by the sample was taken after 30 min.

Foam stability

The foam stability (FS) was determined according the method described by Chandra et al. (2015). 1g flour sample was added to 50 ml distilled water at $30 \pm 2^\circ\text{C}$ in a graduated cylinder. The suspension was mixed and shaken for 5 min to foam. The foam volume was recorded 1 hour after whipping. The foam stability was determined as a percentage of initial foam volume.

Sensory evaluation

The organoleptic evaluation of the biscuits samples was carried out for consumer acceptance and preference using 25 trained panelists. They were to evaluate the sensory properties based on; colour, aroma, taste, texture and overall acceptability using a 9 (nine) point

hedonic scale where 1 represents “extremely dislike” and 9 “extremely like” respectively.

Statistical Analysis

All data derived from experimental work were statistically analysed using the Statistical Package for the Social Sciences v. 20.0 (SPSS, Chicago, IL, USA). The means were compared with aid of a one-way ANOVA and a significance level of $p < 0.05$ was set. The Duncan's multiple comparison post hoc test was used in interpreting the differences among the mean values.

RESULTS AND DISCUSSION

Proximate composition of composite flours

The proximate composition of the composite flours is presented in Table 2. The ash content of the flour samples ranged between 2.35 to 3.24% compared to WWF (1.15%). This showed that incorporation of beniseed may enhance the amount of mineral intake in the food product and as such would contribute appreciable dietary amounts of mineral (Osidiye, 2012; Afolabi et al. 2001). The moisture content of the substituted flour samples ranged from 12.15 to 9.86% with WBT3 having the highest value. The moisture content is an index of the shelf stability of a product. The fat content the composite flours ranged from 0.78% to 6.25% when compared to wheat flour (0.35%). The progressive increase in the fat contents of the products may be attributable to addition of full-fat beniseed flour, which is an oil seed. Ayo et al. (2010) reported a non-significant difference in the fat content of defatted beniseed and Acha flour. However, Oloyo (1999) reported a significant increase in fat content of “Kokoro” enriched with beniseed.

The protein content of the substituted flours increased significantly ($p < 0.05$) WBT1 (9.26%), WBT2 (9.87%) and WBT3 (10.0%) when compared to WF (9.12%). This increase is due to the high protein content of beniseed and trifoliolate yam flours. Similar findings were reported by earlier workers (Afolabi 2001; Ayo et al. 2010). Aloba (2006) reported that the beniseed has a good balance of amino acids with a chemical score of 62% and a net protein utilization of 54%.

Table 2. Proximate composition of flour samples

Samples	Ash (%)	Moisture (%)	Fat (%)	Protein (%)	Crude fibre (%)	Carbohydrate (%)
WWF	1.15 ^a	13.14 ^d	0.35 ^a	9.12 ^a	0.25 ^a	76.02 ^d
WBT1	2.35 ^b	12.15 ^c	0.78 ^b	9.26 ^b	0.49 ^b	74.99 ^c
WBT2	2.95 ^c	11.88 ^b	1.49 ^c	9.87 ^c	0.98 ^c	72.85 ^b
WBT3	3.24 ^d	9.86 ^a	6.25 ^d	10.00 ^d	2.76 ^d	67.91 ^a

*Values within the same column with different superscript letters are significantly different ($p < 0.05$) from each other WWF; Whole Wheat flour, WBT1, 90% Wheat flour+5% Beniseed flour+ 5% Trifoliolate yam flour, WBT2; 70% Wheat flour+15% Beniseed flour+ 15% Trifoliolate yam flour, WBT3; 50% Wheat flour+25% Beniseed flour+ 25% Trifoliolate yam flour

Table 3 .Functional properties of flour samples

Samples	Bulk density (g/ml)	Swelling capacity (ml)	Water absorption capacity (%)	Foam stability (%)
WWF	0.74 ^c	8.36 ^b	60.75 ^a	52.24 ^a
WBT1	0.66 ^b	6.85 ^c	149.92 ^d	56.36 ^b
WBT2	0.58 ^a	5.75 ^a	133.03 ^c	71.24 ^c
WBT3	0.57 ^a	6.40 ^b	128.42 ^b	76.33 ^d

*Values within the same column with different superscript letters are significantly different ($p < 0.05$) from each other. WWF; Whole Wheat flour, WBT1, 90% Wheat flour+5% Beniseed flour+ 5% Trifoliolate yam flour, WBT2; 70% Wheat flour+15% Beniseed flour+ 15% Trifoliolate yam flour, WBT3; 50% Wheat flour+25% Beniseed flour+ 25% Trifoliolate yam flour

There was a significant difference between the crude fiber content of the wheat flour and the composite flours ($p < 0.05$). Fiber is regarded as essential, as it absorbs water and provides roughage for the bowels, assisting intestinal transit. Abiodun et al. (2010) reported an increase in fiber content when yam flour was fortified with soybean however Ayindeet al. (2012) reported a decrease in fibre content of "Kokoro"fortified with beniseed. The carbohydrate content decreased as the substitution levels increased. This was in agreement with the findings of Jimoh and Olatidoye (2009) and Emmanuel-Ikpeme et al. (2012), who reported a decrease in carbohydrate content with increase in soybean flour fortification.

Functional properties of flour samples

The functional properties of the flour blends are presented in table 3. The bulk density (BD) of the composite flour was in this order; WBT1 > WBT2 > WBT3 (0.66g/ml > 0.58g/ml > 0.57g/ml respectively). However, WWF had a higher BD than the composite flours (0.74g/ml). This indicates that a lesser package requirement is required with increase in beniseed and trifoliolate yam flour substitution in comparison to WWF. Swelling capacity (SC) is the ability of the starch inherent in flour to hold water through hydrogen bonding. The swelling capacity of flours depends on; size of particles, types of variety and types of processing methods

(Samsher, 2013). There was a significant difference ($p < 0.05$) in the SC of the flour blends; WBT1 > WBT3 > WBT2; (6.85 ml, 6.40 ml and 5.75ml respectively). However, WWF had a better SC (8.36%) when compared to the composite flours. Water absorption capacity (WAC) of a flour is the ability of its particles to entrap large amounts of water such that exudation is prevented (Hsu et al. 2003). It varies with size, shape, the presence of proteins and carbohydrates. WWF had an attenuated WAC (60.75%) in comparison with the composite flours. A similar trend as seen the BD results was observed. Increase in substitution markedly decreased the WAC of the flour samples (149.92% to 128.42%) which implies that the WBT1 sample was the most hydrophilic and WBT3 being hydrophobic. The foam stability of the composite flour samples increased sharply with increasing beniseed and trifoliolate yam substitution; WBT1 < WBT2 < WBT3 (56.36%, 71.24% and 76.33% respectively). The highest foam capacity was observed for the WBT3 sample which could be attributed to a higher protein content. Protein in the dispersion may cause a lowering of the surface tension at the water-air interface (forms a continuous cohesive film around the air bubbles) (Kaushal et al. 2012).

Some mineral composition of composite flours

The mineral composition of the composite flours are shown in table 4. Substitution increase of beniseed and

Table 4 . Some micronutrient composition of flour samples

Samples	Magnesium (%)	Manganese (%)	Sodium (%)	Calcium (%)	Iron (%)	Copper (%)
WWF	0.16 ^a	0.02 ^a	0.60 ^a	0.39 ^a	0.62 ^b	0.31 ^a
WBT1	0.38 ^b	0.01 ^a	0.93 ^b	0.51 ^b	0.53 ^a	0.58 ^b
WBT2	0.46 ^c	0.05 ^b	1.04 ^c	0.70 ^c	0.56 ^a	0.66 ^c
WBT3	0.65 ^d	0.08 ^c	1.07 ^c	0.89 ^d	0.62 ^b	0.73 ^d

*Values within the same column with different superscript letters are significantly different ($p < 0.05$) from each other WWF; Whole Wheat flour, WBT1; 90% Wheat flour+5% Beniseed flour+ 5% Trifoliolate yam flour, WBT2; 70% Wheat flour+15% Beniseed flour+ 15% Trifoliolate yam flour, WBT3; 50% Wheat flour+25% Beniseed flour+ 25% Trifoliolate yam flour

Table 5. Proximate composition of biscuit samples

Samples	Ash (%)	Moisture (%)	Fat (%)	Protein (%)	Crude fibre (%)	Carbohydrat (%)
WWFB	2.29 ^a	7.25 ^d	10.89 ^a	9.83 ^a	0.37 ^a	69.39 ^d
WBTB1	2.65 ^b	6.17 ^c	12.13 ^b	10.10 ^b	0.68 ^b	68.08 ^c
WBTB2	2.72 ^c	5.03 ^b	13.83 ^c	11.32 ^c	1.01 ^c	66.10 ^b
WBTB3	3.45 ^d	4.50 ^a	14.92 ^d	13.59 ^d	1.98 ^d	61.84 ^a

*Values within the same column with different superscript letters are significantly different ($p < 0.05$) from each other. WWFB; Whole Wheat flour biscuit; WBTB1; 90% Wheat flour+5% Beniseed flour+ 5% Trifoliolate yam flour biscuit, WBTB2; 70% Wheat flour+15% Beniseed flour+ 15% Trifoliolate yam flour biscuit, WBTB3; 50% Wheat flour+25% Beniseed flour+ 25% Trifoliolate yam flour biscuit

trifoliolate yam flours resulted in a progressive increase in the mineral content of the composite flours. Iron forms a constituent of hemoglobin which takes part in the transportation of oxygen from the lungs to the tissue. There was no significant difference ($p > 0.05$) seen between WBT3 and WWF with respect to iron content. The magnesium content of the composite flours ranged from 0.38 to 0.65% and were significantly higher ($p < 0.05$) than WWF (0.16%). Magnesium plays an important role in normal calcium and phosphorus metabolism in man. Furthermore, a similar trend of WBT1 < WBT2 < WBT3 in terms of the manganese content was also seen. Although no significant effect ($p > 0.05$) was observed between WWF and WBT1 samples.

Manganese functions in many enzymes and it activates certain enzymes which take part in the digestion and metabolism of carbohydrates, proteins and lipids. Sodium is essential for normal functioning of the body and it also plays a role in the regulation of acid-base balance and water metabolism in the body. In addition, there was a similar increase in both the calcium and copper contents (0.38% and 0.15%, respectively). Calcium is a micronutrient essential to health and wellbeing. It performs diverse biological function in the human body. It serves as; a second messenger for nearly every biological process, stabilizes protein and calcium as well as necessary for normal ossification of bones and normal nerve impulse transmission (Weaver and Heaney, 2006; Raheena 2007). Also, copper stimulates the absorption of iron and it is a constituent of the elastic connective tissue protein elastin. Potassium is an important constituent of cells and it helps with muscular function.

Proximate composition of the composite flour biscuits

The proximate composition of the composite flour biscuits are presented in table 5. The proximate composition of the composite flour biscuit samples showed a similar trend with their parents. There was a significant elevation ($p < 0.05$) of the ash content of biscuit samples as substitution levels of beniseed and Trifoliolate yam increased (2.65 to 3.45%). The ash contents of all the composite flour biscuit samples were significantly higher than WWB (2.29%). Likewise, the fat content of the biscuit samples was also boosted significantly ($p < 0.05$) (12.13 to 14.92 %) and were all higher than WWB (10.89%). This increase in the fat content may be due to the appreciable amount of fat in the beniseed seeds. Similarly, the protein composition of the composite flour biscuits significantly progressed ($p < 0.05$) as substitution levels increased (10.10-13.59%). The composite flour biscuit samples had a better protein quality than WWB (9.83). This increase is apparently attributed to the protein in sesame seeds (El-Adawy, 1997). Furthermore, a significant increase ($p < 0.05$) was also seen in the crude fiber content of the biscuit samples (0.68-1.98%) which was higher than WWB (0.37). High fibre is beneficial to the body, as it could help to maintain bowel integrity, lower blood cholesterol level, and control blood sugar level, hence consumption of these products would provide appreciable amount of fiber to the body for proper functioning of the digestive and excretory systems. Conversely, biscuits made from with higher of beniseed and Trifoliolate yam had a reducing effect on both moisture content and carbohydrate contents and were significantly

Table 6. Sensory characteristics of the beniseed, trifoliolate yam and wheat flour biscuit

Samples	Colour	Texture	Aroma	Taste	Flavor	Crispness	Overall Acceptability
WWFB	6.67 ^b	6.07 ^b	5.80 ^a	5.13 ^b	5.47 ^b	6.40 ^b	5.87 ^a
WBTB1	8.07 ^a	7.80 ^a	8.13 ^b	8.27 ^d	7.93 ^d	8.00 ^c	8.33 ^c
WBTB2	6.00 ^b	6.67 ^a	8.00 ^b	6.93 ^c	6.73 ^c	6.80 ^b	7.40 ^b
WBTB3	5.73 ^c	5.73 ^c	6.07 ^a	4.13 ^a	4.53 ^a	5.53 ^a	5.93 ^a

*Values within the same column with different superscript letters are significantly different ($p < 0.05$) from each other. WWFB; Whole Wheat flour biscuit; WBTB1: 90% Wheat flour+5% Beniseed flour+ 5% Trifoliolate yam flour biscuit, WBTB2; 70% Wheat flour+15% Beniseed flour+ 15% Trifoliolate yam flour biscuit, WBTB3; 50% Wheat flour+25% Beniseed flour+ 25% Trifoliolate yam flour biscuit

lesser ($P < 0.05$) than WWB (7.25% and 69.39% respectively). The moisture content of biscuit samples significantly decreased (6.17% - 4.50%). Christine et al.(2012) reported a similar trend in bread and cake samples produced from beniseed and wheat composite flour. Similarly, the carbohydrate contents slumped significantly (68.08-61.84%) ($p < 0.05$).

Sensory characteristics of composite flour biscuits

The result for sensory evaluation is presented in table 6. The biscuit samples were evaluated for colour, texture, aroma, taste, flavor, crispness and overall acceptability. In terms colour, there was a significant difference ($p < 0.05$) observed by the panelists but WBTB1 was most preferred (8.07). However, there was no significant difference ($p < 0.05$) seen between WBTB2 and WWFB (6.00 and 6.67 respectively) but WWFB was most preferred. A significant difference ($p < 0.05$) in texture was detected by the panelist with WBTB1 having the highest preference (7.80). Though no significant difference ($p < 0.05$) was perceived between WBTB1 and WBTB2 (7.80 and 6.67 respectively) but WBTB1 was most preferred. Aroma was perceived to be significantly different ($p < 0.05$) among the samples with WBTB1 having the highest score of 8.13. In addition, WWFB and WBTB3 as well as WBTB1 and WBTB2 were not significantly different ($p < 0.05$) from each other (5.80 and 6.07 respectively) and (8.13 and 8.00 respectively). Taking a look at taste and flavor, it was discovered that there was a significant difference in all the samples ($p < 0.05$) with WBTB1 being the most desired (8.27 and 7.93 respectively). Also, there was a significant difference in crispiness of the biscuits ($p < 0.05$) with WBTB1 being the most desirable (8.00%). However, there was no significant difference seen between WFB and WBTB2 (6.40 and 6.80). Furthermore, the most accepted biscuit sample was that of WBTB1 (8.33). WWFB was the least accepted (5.87), moreover, it was not significant different ($p > 0.05$) from WBTB3.

CONCLUSION

The research reveals that the inclusion of beniseed and trifoliolate yam flour improved the proximate composition,

and mineral quality of flour samples as well as the biscuits produced. Although, it had a poor effect on the carbohydrate and moisture contents. In addition, blending beniseed with trifoliolate yam flour up to 15% level produced samples which can be used for the production of bakery products with improved functional properties and production time. Also, the inclusion of beniseed and trifoliolate yam flours improved some sensory parameters which could be further investigated. The biscuits produced with 5% beniseed and trifoliolate yam flours (WBTB1) had the highest overall acceptability. This establishes the fact that the inclusion of 5% beniseed and trifoliolate yam flours will compete favorably with whole wheat flour in terms of biscuit production. Therefore, this study has provided further insight the suitability of cereal-tuber based flours as a suitable adjunct to whole wheat flour utilisability in the baking industry. Also, most especially, in the utilization of trifoliolate yam which has proven to be difficult to process.

REFERENCES

- AOAC (1990). Official methods of Analysis of the Association of Official Analytical Chemists, 15th edn. AOAC, USA.
- Abou-Garbia HA, Shehata AAY, Shahidi F (2000). Effect of Processing on oxidative stability and lipid classes of Sesame oil. *Food Res Intl* 33: 331-340.
- Afolabi WAO, Oguntona CRB, Fakunmoju BB (2001). Acceptability and chemical composition of bread from beniseed composite flour. *J Nutr Food Sci* 31(6): 310-313.
- Akanji AM, Ologhobo AD, Emiola IA, Oladunjoye IO (2003). Effect of raw and differently processed sesame seeds and performance and nutrition utilization of broiler chickens. *Proceedings of the 28th Annual Conference of the Nigerian Society of Animal Production* 23: 184-186.
- AOAC. (2004). Official methods of Analysis, 15th edn. Association of official Analytical Chemistry, USA, pp 806-842.
- Alobo AP (2006). Effect of sesame seed on millet biscuit. *J Plant Foods Hum Nutr* 64: 21-27.
- Abiodun, OA, Adegbite JA, Oladipo TS (2010). Effect of cassava starch substitution on the functional and sensory properties of trifoliolate yam (*Dioscorea dumetorum*) flours. *Afr J Food Agric Nutr Dev* 10(7).
- Ayo JA, Ikuomola DS, Esan YO, Onuoha OG, Ayo VA, Ekele V (2010). Effect of added defatted beniseed on the quality of Acha based biscuits. *Cont J Food Sci Technol* 4: 7-13.
- Ayinde FA, Bolaji OT, Abdulsalaam RB, Osidipe O (2012). Functional properties and quality evaluation of kokoro blended with beniseed cake (*Sesame indicum*). *Afr J Food Sci* 6(5):117-123.
- Adeniyani OO, Ibukun EO1, Ogunbolude Y, Esegibe MI. (2013). Effect of Boiling on the Nutritional composition and antioxidant properties of Beniseed (*Sesamum indicum L.*) *Food Sci Qual Manag*. 11: 40 – 48.

- Abiodun OA, Akinoso R J (2015). Textural and sensory properties of trifoliate yam (*Dioscorea dumetorum*) flour and stiff dough 'amala'. *J Food Sci Technol* 52: 2894.
- Ceirwyn SJ (1998). *Analytical Chemistry of Food*. Chapman and Hall, London, pp 75-77.
- Christine EI, Christopher E, Godwin I (2012). Nutritional and organoleptic properties of wheat (*Triticum aestivum*) and beniseed (*Sesame indicum*) composite flour baked foods. *J Food Res* 1(3): 84-91.
- Chandra S, Singh S, Kumari DJ, (2015). Evaluation of functional properties of composite flours and sensorial attributes of composite flour biscuits. *Food Sci Technol* 52: 3681.
- Dawodu, FA (2009). Physico-chemical studies on oil extraction processes from some Nigerian grown plant seeds. *Electronic Journal of Environmental, Agricultural and Food Chemistry*, 8(2): 102-110.
- EI-Adawy TA (1997). Effect of sesame seed protein supplementation on the nutrition, physical, chemical and sensory properties of wheat flour bread. *Food Chem* 59:7-14.
- Ezeocha VC, Omodamiro RM, Oti E, Chukwu GO (2011). Development of trifoliate yam: Cocoyam composite flour for fufu production. *J Stored Prod Posthar Res* 2(9): 184-188.
- Eke-Ejiofor J, Owuno F (2012). Functional and Pasting Properties of Wheat/Three-leaved Yam (*Dioscorea dumentorum*) composite flour blend. *Global Res J Agric Bio Sci* 3(4): 330-335.
- Emmanuel-Ikpeme C, Eneji C, Igile G (2012). Nutritional and organoleptic properties of wheat (*Triticum aestivum*) and beniseed (*Sesame indicum*) composite flour baked foods. *J Food Res* 1(3): 84.
- FAO (2003). *Yams: Post-Harvest Operation*. Food and Agricultural Organisation, New Zealand.
- Hsu CL, Chen W, Weng YM, Tseng CY (2003). Chemical composition, physical properties, and antioxidant activities of yam flours as affected by different drying methods. *Food Chem*, 83(1): 85-92.
- Himeda M, Yanou, N., Fombang, E, Facho B, Kitissou P, Mbofung CMF, Scher J (2014). Chemical composition, functional and sensory characteristics of wheat-taro composite flours and biscuits. *J Food Sci Technol* 51: 1893.
- Igbabul, B, Adole, D, Sule, S. (2013). Proximate composition, functional and sensory properties of bambara nut (*Voandzeia subterranean*), cassava (*Manihot esculentus*) and soybean (*Glycine max*) flour blends for "Akpekpa" production. *Current Research in Nutrition and Food Sci J.*, 1(2): 147-155.
- Jimoh KO, Olatidoye OP (2009). Evaluation of physicochemical and rheological characteristics of soybean fortified yam flour. *J Appl Biosci* 13: 703-706.
- Kaushal P, Kumar V, Sharma HK (2012). Comparative study of physicochemical, functional, anti-nutritional and pasting properties of taro (*Colocasia esculenta*), rice (*Oryza sativa*), pigeon pea (*Cajanus cajan*) flour and their blends. *LWT-Food Sci Technol* 48: 59-68.
- Martin FE, Degras L (1978). Tropical yams and their potentials. part 6. minor cultivated *Dioscorea* species. *Agricultural Handbook No. 538*, USDA, pp. 23.
- Mohammed MI, Hamza ZU (2008). Physicochemical properties of oil extracts from *Sesamum indicum* L. seeds grown in Jigawa state, Nigeria. *J Appl Sci Environ Man* 12(2): 99-101.
- Morris JB (2002). Food, industrial, nutraceutical, and pharmaceutical uses of sesame genetic resources. *Trends in new crops and new uses*, pp 153-156.
- Narayana K, Narasinga RMS (1982). Functional properties of raw and heat processed winged bean (*Psophocarpus tetragonolobus*) flour. *J Food Sci*, 47(5): 1534-1538. In: Janick J, Whipkey A (eds) *New Crops and New Uses*, ASHS, Alexandria, pp 153-156.
- Njoku OU, Boniface JE, Obitte NC, Odimegwu DC, Ogbu HI (2009). Some nutraceutical potential of beniseed oil. *Intl J Applied Res Nat Prod* 2(4): 11-19.
- Ogbuagu MN (2008). Nutritive and Anti-Nutritive Composition of the Wild (In-Edible) Species of *Dioscorea bulbifera* (Potato Yam) and *Dioscorea dumentorum* (Bitter Yam). *J Food Technol*, 6(5): 224-226.
- Okaka JC, Potter NN (1977). Functional and storage properties of cowpea-wheat flour blends in bread making. *J Food Sci* 42:828-833.
- Oloyo RA (1999). Some aspect of nutritive quality of some maize based traditional convenience foods Niger. *Food J* 22:61.
- Osidiye O (2012). Functional properties and quality evaluation of kokoro blended with beniseed cake *Sesame Indicum*. *Afr J Food Sci* 6(5):117-123.
- Raheena B (2007). *A text book of foods, nutrition & dietetics*. Sterling Publication Pvt. Ltd.
- Samsner CS (2013). Assessment of functional properties of different flours. *African J. Agricultural Research* 8(38):4849-4852.
- Sefa-Dedeh SK, Afoakwa EO (2001). Biochemical and textural changes in trifoliate yam (*Dioscorea dumetorum*) tubers after harvest. *IFT Annual meeting-New Orleans, Louisiana*.
- Sosulski FW, Garratt MO, Slinkard AE (1976). Functional properties of ten legume flours. *Intl J Food Sci Technol* 9:66-69.
- Uaboi-Egbenni PO, Sobande AO, Okolie PN, Teniola O, Ofodiogo C (2008). Proximate composition of whole, dehulled and fermented beniseed (*sesame indicum*) with associated bacterial species. *Nig Food J*, 26(1).
- USDA (2009). *United States Department of Agriculture National Nutrient Database for Standard Reference, Release 22*.
- Weiss EA (2000). *Oil Seed Crop*. 2nd edn. Blackwell Longman, USA, pp 131-164.
- Weaver CM, Heaney RP (2006). Food sources, supplements, and bioavailability. In *calcium in human health*, Humana Press, pp 129-142.