Quality Evaluation of Biscuits Produced from the Blends of Acha-Tangerine Peels Flour

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ABSTRACT

Biscuits were produced from the blends of *Acha and tangerine* peel flour. The biscuits were then evaluated for the proximate composition, Phytochemicals, minerals and vitamins and sensory properties. The result of the study indicate the break strength (2.52-3.00 kg) and thickness (0.70-0.75 mm) of the biscuit to increase with decrease in spread ratio (6.70-5.57) and diameter (4.69-4.17cm) of the biscuits samples as the level of tangerine peel flour increases. The loose density, packed density, water absorption capacity and swelling capacity increased from 0.53-0.75, 0.40-1.05 and 7.05-7.95mg/100g, respectively. Pasting properties result showed a decreasing level of trough (134.49-115.35) RVU, pasting time (7.00-5.10)mins, pasting temperature (57.23-59.34°C), peak viscosity (204.00-151.64) RVU, and breakdown viscosity (69.51-36.29) RVU, while the final viscosity (344.71-352.48)RVU and set back (222.75-246.07)RVU increased with increasing level of tangerine peel flour addition. The moisture, ash, and crude fiber, and fat increased from 3.49-3.50, 0.98-1.20, and 1.72-2.0%, while the fat and protein decreased from 14.57-14.26, 5.39-5.10% with increase in the added tangerine peel flour (5-20%). The potassium, phosphorus, magnesium, calcium, iron, vitamin A, vitamin B1, vitamin B2, vitamin B6, vitamin B3, and vitamin C of the flour blend biscuits increased from 132.61-186.69, 25.70-39.71, 40.78-62.37, 78.56-93.52, 15.67- 32.42, 14.10-14.95, 0.26-0.34, 0.32-0.36, 0.07-0.08, 1.34-1.43, and 0.17-0.27mg/g, respectively with increase in the level of tangerine peel flour addition. The phenols, *flavonoid, phytate*, and tannins content of the flour blend biscuits increased from 0.64-1.64, 0.05-0.08, 0.19-0.22, and 0.19-0.24 mg/100 g, respectively, with increase in added tangerine peel flour. The biscuit blends containing 5% tangerine peel flour had the highest scores for all sensory attributes except for texture. The *acha-tangerine* peel biscuit blend was generally accepted up to 15%, but most preferred at 5% added tangerine peel flour. The tangerine peel flour could be used to enrich the quality of food products.

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INTRODUCTION

Biscuits are flour based products that are edible. They also regarded as a form of confectionery dried to very low moisture content (Hussein *et al.,* 2006). The simplest form of biscuit is a mixture of flour (wheat flour), water, fat, sugar and other ingredients which are mixed together into a dough which is rested for a period, passed between rollers to make a sheet; the sheet is then stamped out, baked cooled and packaged (Hussein *et al.,* 2006). Generally biscuits have high fat and sugar levels and at the same time, low water level.

Biscuits have been classified by Okaka and Isieh, (1990) into four different categories according to their sugar levels. Soft-dough biscuits containing 25% sugar; digestive with 32% sugar; short cake or flow-type biscuits containing 59% sugar (schellford) and ginger nuts with 79% sugar. The nutritional value of biscuits varies with the type of cereal used. Biscuit is known to generally contain fat (18.5%), carbohydrate (78.23%), ash (1.0%), and protein (7.1%) and salt (0.85%) (Okeagu, 2001).

In baking industry, wheat is a widely preferred cereal and most commonly used in biscuit production because of its unique rheological properties imparting positive effect on baking quality. Importation of wheat flour has led to high cost of production of baked products, hence locally cultivated and available cereals crop (acha) could be an alternative in Nigeria. The underutilization of tangerine peels despite its relative high phytochemical composition, with its pollution of the environment, when not properly disposed, has urgently called for research for alternative use. The peel and seeds results in a considerable amount of by-products which might be a source of environmental pollution since they are prone to microbial spoilage. The constant increase in the cost wheat flour, which is the principal raw material, has called for research into an alternative cereal such as acha, millet and sorghum.

Acha (*Digitariaexillis*) is a cereal grain in the family of *gramineae* and commonly referred to as *fonio* or hungry rice (Alamu, 2001). Acha is mostly consumed whole; perhaps because of its small size (Jideani and Akingbala, 1993). Consumption of the acha as whole grain makes it an excellent source of dietary fiber and its associated nutraceutical benefits is suitable for the health challenged groups such as obesity and diabetes (Kasarda, 2001; Kahlon, 2009). Like other emerging ancient grains, acha grains with excellent culinary and nutritional properties have potential in new product development having unique sulphur containing amino acids. Whole acha is now used for quick cooking, non-conventional food products including weaning foods of low bulk density and breakfast cereal with good fiber content (Jideani,1990). Whole grain acha flours can be used in the preparation of a number of biscuits and snacks that could be useful for individuals with gluten intolerance (Ayo and Nkama, 2003).

Acha protein has nutritional composition similar to that of white rice (Temple and Bassa, 1991 ; Jideani and Akingbala, 1993), Though it is relatively higher sulphur amino acid (methionine and cystine) content (Lumen *et al*., 1993; Lasekan, 1994 ; Jideani *et al*., 1994) than the white rice. Sulphur amino acids are crucial for proper heart function and nerve transmission.

In recent study, acha grain has shown to have high water absorption capacity, a property that could be linked to appreciable amount of pentosan. The high water absorption capacity of acha could be utilized in baked food. Pentosan has been found to be a very important regulator of water absorption and in dough (Ayo and Kajo, 2016).

Orange is the world`s most popular fruit. It constitutes about 60% of the total citrus world production (Ibrahim, 2012). Annually more than 55 million tons of oranges are grown globally out of which 80 percentage of the oranges produced are processed in industry for juice production (Hegde *et al.,* 2015). Orange fruit extracts are used as functional ingredients in several industrial products and these industrial activities generate humongous quantities of wastes(peels, seeds and pulps) rich in polyphenol that are often disposed into the environment apart from using only as animal feed. Main phenolic constituents of citrus fruits are flavonone and flavone glycosides, hydroxycinnamates, coumarines, psoralens and polymethoxyalted flavones (Hegde et al., 2015). In contrast with other types of fruits, about 34% of the fruit is used for juice production, yielding about 44% of peels as by products (Omoba, 2015).

Tangerine *(Citrus reticulata)* fruits have peculiar fragrance partly due to flavonoids and limonoids present in the peel and these fruits are good sources of vitamin C and flavonoids. Tangerine peels are a rich source of Vitamin C which is considered as an important water-soluble antioxidant. The major role of vitamin C is the prevention of scurvy; this causes the disease which leads to the formation of spots on the skin, spongy gums and bleeding from the mucous membranes (Ibrahim, 2012).

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Tangerine peels are generally wasted when the fruits are mainly used by juice processing industries. The juice yield of citrus is less half of the fruit weight. Flavonoids are a group of natural compounds with variable phenolic structures and are found in plants, they are oxidized by radicals, resulting in a more stable, less-reactive radical (Ibrahim, 2012).

MATERIALS AND METHODS

Materials

Acha grains (*Digitaria exilis*) were purchased from a local market in Jos while tangerines (*citrus reticulata*) were purchased from Gboko market, Benue State. Baking fats(Vitali), baking powder(De royal star), salt (Royal salt ltd), sugar (Dangote sugar) and wheat flour (Dangote flour) were purchased from Gboko local markets in Benue State. Analytical grade chemicals were obtained from Department of Food Science and Technology laboratory, University of Mkar, Mkar.

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Preparation of Acha and Tangerine Flour

Acha grains were cleaned manually by hand picking the dirts. Stones were removed by washing in clean water (sedimentation). The washed and de-stoned grains were oven dried at $45^{o}C$ for 3hrs and then milled using milling machine (model R175A). The flour was sieved (0.3 mn aperture), packaged (polyethylene) and stored under room temperature ($27^{o}C$).

The tangerine fruits were sorted, washed and peeled with hands. The peels were cut into smaller units and oven dried ($45^{o}C$), milled (attrition mill), sieved (1µm sieve) packaged (polyethylene bag) and stored at room temperature $27^{o}C$.

Formulation of Blends

Acha and orange peel flours were blended at different proportions at (100:0; 95:5; .90:10; 85:15, 80:20 and 100:0%). The 100% wheat flour served as control (Table 3.1). The blends were thoroughly mixed and kept in plastics containers until needed.

Analysis

Determination of Proximate Composition of acha - tangerine peel flour blends

The protein, fat, ash, crude fibre and moisture content of the samples were determined using AOAC (2012) method. The carbohydrate content was calculated by difference.

Determination of Functional Properties of acha - tangerine peel flour blends

The functional properties (water absorption capacity, oil absorption capacity, emulsifying capacity, bulk density and foam capacity) were determined as described by Onwuka(2005).

Determination of Physical Analysis of Tangerine-Acha flour blend biscuits

The spread ratio, break strength, pasting properties of the tangerine- Acha flour blend biscuits were determined by Gomez *et al*., 1997, Okaka and Isieh's (1997), respectively.

Determination of Phytochemical Composition of Tangerine-Acha Flour Biscuits Blend Biscuits

The flavonoids, alkaloids, oxalate, phytate, HCN and phenol content of the flour blends were determined by Sofowora (1982), Harborne (1973) and Trease and Evans (1989).

Determination of Sensory Properties of Tangerine-Acha flour blend biscuits

The sensory evaluation of the samples was carried out for consumer acceptance and preference using randomly selected 20 untrained judges (students and staff of the Department of Food Science and Technology, University of Mkar, Benue State, Nigeria). The panellists were instructed to evaluate the coded samples for colour, crispiness, aroma, taste, texture, and general acceptability. Each sensory attribute was rated on a 9-pointHedonic scale (1= dislike extremely and 9=like extremely). The panellists were offered distilled water to rinse their mouth between evaluations (Iwe, 2002)

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Statistical Analysis

The results obtained from the various analyses were subjected to Analysis of Variance (ANOVA) using Statistical Package for Social Sciences (SPSS) version 20.0. Means were separated with Duncan Multiple Range Test (DMRT) at 95% confidence level ($p \leq 0.05$).

RESULTS AND DISCUSSION

Effect of added tangerine peel flour on the chemical composition of Acha-Tangerine Peel Flour Biscuit

Proximate Composition of Acha-Tangerine Peel Flour Biscuit

The effect of added tangerine peel flour on the proximate composition is shown in Table 1

The increase in the addition of tangerine peel flour (5-20%) showed no significant difference in the moisture content. This could be due to the relatively increase in the fibre content of the added tangerine peel from the blends. Fibre has the ability of absorbing moisture. The lower the moisture contents of a product, the better the shelf stability of such product (Sanni *et al*., 2008), because low moisture ensures shelf stability in dried products. Thus, low moisture content in confectionaries such as biscuit is an advantage as it will bring about reduction in microbial spoilage and prolonged storage shelf life if stored inside appropriate packaging materials under good environmental condition. The values obtained in this study favourably compares with those reported by Emmanuel- Ikpeme *et al*.,(2012) for different types of commercial biscuits (Khaliduzzan *et al*.,2010) in wheat-potato composite biscuit and (Onabanjo and Ighere, 2014) in wheat-sweet potato composite biscuit.

The ash content showed a significant difference

Table 1: Proximate Composition of Acha-Tangerine Peel Biscuit

Acha:Tangerine peel flour(%)	Moisture (%)	Ash (%)	Crude Protein(%)	Crude Fat (%)	Crude Fiber(%)	Carbohydrate(%)
A	$5.01{\pm}0.01^{c}$	$2.23{\pm}0.01^{e}$	$5.48{\pm}0.22^{a}$	$15.84{\pm}0.01^{f}$	$1.32{\pm}0.01^{b}$	$70.12{\pm}0.19^{a}$
B	$4.09{\pm}0.03^{b}$	$2.05{\pm}0.01^{e}$	$6.35{\pm}0.01^{b}$	$15.22{\pm}0.01^{e}$	$1.19{\pm}0.01^{a}$	$71.10{\pm}0.03^{b}$
C	$3.49{\pm}0.05^{a}$	$0.98{\pm}0.03^{a}$	$5.39{\pm}0.07^{a}$	$14.57{\pm}0.07^{d}$	$1.72{\pm}0.04^{c}$	$73.85{\pm}0.08^{c}$
D	$3.49{\pm}0.01^{a}$	$1.05{\pm}0.01^{b}$	$5.31{\pm}0.01^{a}$	$14.46{\pm}0.01^{c}$	$1.79{\pm}0.01^{d}$	$73.90{\pm}0.05^{c}$
E	$3.49{\pm}0.06^{a}$	$1.11{\pm}0.04^{c}$	$5.23{\pm}0.06^{a}$	$14.35{\pm}0.03^{b}$	$1.85{\pm}0.04^{e}$	$73.97{\pm}0.09^{c}$
F	$3.50{\pm}0.04^{a}$	$1.18{\pm}0.03^{d}$	$5.13{\pm}0.27^{a}$	$14.20{\pm}0.04^{a}$	$2.00{\pm}0.03^{f}$	$73.99{\pm}0.24^{c}$

Values are presented as means ± SD. Values with different superscript within the same column are significantly different (p=0.05).

Key: *A = 100% WF, B =100% AF, C = 95% AF; 5% TF, D = 90% AF; 10% TF, E = 85% AF; 15% TF, F = 80% AF; 20%*

TF. Where AF = Acha Flour, WF = Wheat Flour and TF = Tangerine Peel Flour

with the addition of tangerine peels (5-20%). Increased level of ash/minerals with increase in tangerine peel flour levels could be due to high levels of minerals in tangerine peels as earlier observed by Li *et al.,* (2006). This suggests that tangerine peels could help in boosting the mineral content of acha biscuit. The ash content of any food represents the inorganic residue remaining after all the organic material (moisture, proteins, fats, carbohydrates, vitamins and organic acids etc.) had been burnt away by igniting at temperature approximately 500°C. Ash residue is generally taken to be a measure of the mineral content of the original food and which is generally small (less than 1% of the food) (Onwuka, 2005).

The protein content showed that, with the addition of tangerine peel there was a significant decrease in the protein content. This could be due to the relatively low protein (1%) of the tangerine peels as observed by Cho *et al.* (2014) compared to that of acha grain flour(8.0%).

The fat content showed a decrease with the addition of tangerine peels. The relative low fat content could improve the shelf life of the product (Storggard, 2008).

The fibre content ranged from 2.00% (20% tangerine peel and 80% acha flour) to 1.19% (100% wheat control). Increase in tangerine peel flour (5-20%) increased levels of fibre (1.72-2.06%) and ash (0.98-1.26%) which showed a significant difference at (p=0.05). The increase agreed with the observation (2.6%) of Forbes *et al.*, (2013). Okaka (2006) also reported similar work on bread with increase in fibre content with increase in OPF level. Increase in fibre content may have resulted in its reducing the moisture content of the biscuit samples due to its inherent functional property as observed by Forbes et al., (2013). Fibre facilitates bowel movements; prevents constipation and unhealthy development of diseases like appendicitis, gall stones, haemorrhoids and tumours of the colon and rectum. The importance of dietary fibre is that it composes of pectin, cellulose and other hydro-colloids is a remedy for treating medical issues like lowering of cholesterol and triglyceride lipid increase levels and blood glucose modulation diabetics.

The Carbohydrate content increased (70.12 73.99%) with increase in tangerine peel flour (5-20%) showing no significant difference. This is as a result of the high content of carbohydrate in acha as reported by Washington, (2001)

Mineral Composition of Acha-Tangerine Peel Flour Biscuit

The results of mineral composition of acha-tangerine peel flour biscuit are presented in Table 2. Potassium content significantly increased with addition of tangerine peels (5-2-%). There was a significant (p=0.05) difference in potassium content, with the exception of samples containing 100% wheat flour and 100% acha flour. The relative high values of the blended flour might be attributed to appreciable inherent amount of potassium content in tangerine peels flour. The value was lower than the 1086.67 to 5350 mg/kg

Table 2: Mineral Composition of Acha-Tangerine Peel Flour Biscuit

Acha:Tangerine peel flour(%)	Potassium(mg/g)	Phosphorus(mg/g)	Magnesium(mg/g)	Calcium(mg/g)	Iron(mg/g)
A	0.24±0.01[a]	0.51±0.01[a]	0.04±0.01[a]	0.18±0.01[a]	8.01±0.01[a]
B	0.22±0.01[a]	0.53±0.01[a]	0.26±0.01[b]	0.26±0.01[a]	7.95±0.01[a]
C	132.61±0.12[b]	94.15±0.01[d]	40.78±0.90[c]	78.56±0.08[b]	15.67±0.22[b]
D	149.13±0.01[c]	81.05±0.01[c]	46.49±0.01[d]	82.18±0.01[c]	20.59±0.01[c]
E	165.64±0.22[d]	39.72±0.16[b]	52.19±9.46[e]	85.80±0.04[d]	25.51±0.13[d]
F	186.69±0.90[e]	39.71±0.06[b]	62.37±0.04[f]	93.52±0.11[e]	32.42±0.07[e]

Values are presented as means ± SD. Values with different superscript within the same column are significantly different (=0.05).
***Key:** A = 100% WF, B =100% AF, C = 95% AF; 5% TF, D = 90% AF; 10% TF, E = 85% AF; 15% TF , F = 80% AF; 20% TF. Where AF = Acha Flour, WF = Wheat Flour and TF = Tangerine Peel Flour.*

for potassium content reported by Opeoluwa *et al*., (2015). The difference might be due to variation in flour and other ingredients used. Potassium is an essential nutrient and has important role in the synthesis of amino acid and protein in man.

Phosphorus decreased with the addition of tangerine peels. The samples were significantly (p=0.05) different in phosphorus content. However, there was no significant difference in phosphorus content of 15% and 20% tangerine peel flour. Phosphorus is the second most abundant mineral in the body after calcium. In form of various phosphates, phosphorus performs a wide variety of essential functions including liberation and utilization of energy from food (Abara, 2011).

The magnesium content of the biscuit samples range from 0.04 to 62.37mg/g. There was no significant (p=0.05) difference in magnesium content of 100% acha (control) and 100% wheat (control). However a significant difference (p=0.05) exist among all of the samples.

Calcium content ranged from 93.52mg/g (20% tangerine peel and 80% acha flour) to 0.18mg/g (100% wheat control). . There was a significant (p = 0.05) difference in the calcium content of 5 - 20% tangerine peel flour addition. Calcium intake in diabetics has been shown to be beneficial and likely to reduce osterophorosis in older diabetics (Cryer, *et al*., 1994).

Iron content increased with increase in tangerine peels (5-20). Iron is an essential element for almost all living organisms as it participates in a wide variety of metabolic processes, including oxygen transport. However, as iron can form free radicals, its concentration in the body tissues must be tightly regulated because in excessive amounts, it can lead to tissue damage (Nazanin, *et al.,* 2019) .

Vitamin Composition of Acha-Tangerine Peel Flour Biscuit

The results of vitamin composition of acha-tangerine peel flour biscuit are presented in Table 3. Vitamin A content increased with increase in tangerine peels (5-20%). Vitamin A helps in vision, bone growth, reproduction, growth of epithelium and fighting infections. Vitamin C contents increased significantly with increase in tangerine peels (5-20). Vitamin C plays an important role in a number of metabolic functions including the activation of the B vitamins, folic acid, the conversion of cholesterol to bile acids, it also protects the body from free radical damage (Shailja *et al.,* 2018). There was no significant (p=0.05) difference in the B vitamin content of the biscuit samples. The vitamin content of biscuit samples containing 10 and 15% tangerine peels addition were seen to be significantly the same. The vitamin content increased with increase in addition tangerine peel flour addition. This is attributed to the rich deposit of the B vitamins in tangerine peels. The values are within the range of 0.157 to 0.477mg/100g as reported by Okafor and Ugwu (2014) in his research works on ready to eat snacks produced with African bread fruit, cashew nut and coconut flour blends.

Table 3: Vitamins Composition of Acha-Tangerine Peel Flour

Acha:Tangerine peel flour(%)	VitaminA (mg/100g)	VitaminC (mg/100g)	VitaminB1 (mg/100g)	VitaminB2 (mg/100g)	VitaminB3 (mg/100g)	VitaminB6 (mg/100g)
A	0.22 ± 0.01^{a}	0.67 ± 0.01^{e}	0.57 ± 0.01^{d}	0.25 ± 0.01^{b}	0.27 ± 0.01^{b}	6.14 ± 2.30^{c}
B	0.11 ± 0.01^{a}	0.56 ± 0.01^{d}	0.46 ± 0.01^{c}	0.19 ± 0.01^{a}	0.22 ± 0.01^{a}	4.55 ± 0.01^{b}
C	14.10 ± 0.04^{b}	0.17 ± 0.03^{a}	0.26 ± 0.02^{a}	0.32 ± 0.00^{c}	1.34 ± 0.02^{c}	0.07 ± 0.00^{a}
D	14.10 ± 0.04^{b}	0.21 ± 0.01^{b}	0.27 ± 0.01^{a}	0.33 ± 0.01^{c}	1.40 ± 0.01^{d}	0.07 ± 0.01^{a}
E	14.37 ± 0.04^{bc}	0.24 ± 0.02^{b}	0.28 ± 0.02^{a}	0.33 ± 0.01^{c}	1.43 ± 0.03^{d}	0.07 ± 0.00^{a}
F	14.95 ± 0.02^{c}	0.27 ± 0.02^{b}	0.34 ± 0.02^{b}	0.36 ± 0.00^{cd}	1.46 ± 0.00^{d}	0.08 ± 0.00^{a}

Values are presented as means ± SD. Values with different superscript within the same column are significantly different (p=0.05).
***Key:** A = 100% WF, B =100% AF, C = 95% AF; 5% TF, D = 90% AF; 10% TF, E = 85% AF; 15% TF , F = 80% AF; 20% TF. Where AF = Acha Flour, WF = Wheat Flour and TF = Tangerine Peel Flour.*

Functional Properties of Acha-Tangerine Peel Flour Biscuit

The results of functional properties of acha-tangerine peel flour biscuit are presented in Table 4. The loose density, increased from 0.53 to 78g/cm^3 this may be due to increase in fibre content. The results are within the reported values (0.69-0.76%) for starch foodstuff (Onuh and Abdulsalam, 2009).

Packed density decreased from 0.69 to 0.50g/cm^3 with increase in the added tangerine peel flour (5-20%) and with a none significant effect (p>0.05) The observation in this work agreed with that of Adeleke and Odedeji (2010).

Water absorption capacity increased slightly with no significant difference with the addition of tangerine peel. According to Kaur and Sing (2005), flours with high water absorption capacity have more hydrophilic constituents, such as polysaccharides. Dewey (2001) stated that carbohydrate content decreases the water absorption capacity of most food systems. The

Table 4: Functional Properties of Acha-Tangerine Peel flour Biscuit

Acha:tangerine Peel flour(%)	Loose Density (g/cm^3)	Packed density (g/cm^3)	Water Absorption capacity ($cm^3/100g$)	Oil Absorption capacity ($cm^3/100g$)	Swelling capacity ($cm^3/100g$)	Foaming Capacity ($cm^3/100g$)	
A	0.63 ± 0.42^{b}	$0.69\pm0.7c$	0.66 ± 0.41^{b}	0.65 ± 0.01^{a}	0.73 ± 0.14^{a}	4.90 ± 0.92^{b}	7.45 ± 0.13^{b}
B	0.53 ± 0.42^{a}	0.63 ± 0.7^{b}	0.56 ± 0.41^{a}	0.62 ± 0.01^{a}	0.70 ± 0.14^{a}	3.90 ± 0.92^{a}	
C	0.58 ± 0.21^{a}	0.58 ± 0.21^{a}	0.90 ± 0.14^{c}	2.85 ± 0.35^{b}	7.18 ± 0.28^{b}	6.38 ± 1.32^{c}	
D	0.61 ± 0.01^{a}	0.57 ± 0.07^{a}	0.95 ± 0.21^{c}	2.80 ± 0.57^{b}	7.20 ± 0.07^{b}	6.35 ± 1.12^{c}	
E	0.68 ± 0.07^{a}	0.52 ± 0.08^{a}	1.00 ± 0.21^{c}	2.80 ± 0.57^{b}	7.25 ± 0.09^{b}	6.35 ± 0.05^{c}	
F	0.78 ± 0.07^{a}	0.50 ± 0.07^{a}	1.05 ± 0.28^{cd}	2.75 ± 0.63^{b}	7.95 ± 0.06^{c}	6.35 ± 0.11^{c}	

Values are presented as means ± SD. Values with different superscript within the same column are significantly different (p<0.05).
Key: *A = 100% WF, B =100% AF, C = 95% AF; 5% TF, D = 90% AF; 10% TF, E = 85% AF; 15% TF , F = 80% AF; 20% TF. Where AF = Acha Flour, WF = Wheat Flour and TF = Tangerine Peel Flour.*

water absorption capacity is the ability of a product to associate with water under limiting conditions in order to improve its handling characteristics and dough making potentials (Singh, 2001; Iwe and Onadipe, 2010 and Giami *et al*., 2004).Samples containing tangerine peels showed no significant difference (5-20%).

Products with high oil absorption capacity have the advantage of improving mouth feel and retention of flavour of the food products in which they are incorporated (Onimawo and Akubor, 2012). However, high oil absorption capacity would be undesirable in some food applications such as those involving deep frying of legume based products like bean ball (akara).

The swelling capacity value of the flour blend increased from 7.18 to 7.95cm^3/100g with increased tangerine peel flour blend (5-20%) and that of water absorption capacity increased from 0.90 to1.05cm^3/100g within increase in tangerine peel flour. These may be due to the presence of fiber content in the orange peel flour. Niba *et al.,* (2001) reported similar existing study that composite flours exhibited higher water absorption capacity and swelling capacity than the control sample (100% whole meal wheat flour).

The foaming capacity decreased from 6.38 to 6.35cm^3/100g with increase in the level of tangerine fruit peel (5-20%). Akubor and Eze (2012) reported similar trend and attributed it to variation in food composition such protein, solubility and other factors

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Pasting Properties of Acha-Tangerine Peel Flour Biscuit

The results of pasting properties of acha-tangerine peel flour biscuit are presented in Table 5.

The highest value was recorded for 100% acha flour control while the lowest value was recorded for 20% acha flour with 80% tangerine peel. There was a significant difference among the biscuit samples (p = 0.05) and it was observed that the higher the quantity of the added tangerine peel, the more the decrease in peak viscosity of the flour samples. The peak viscosity is indicative of the strength of pastes, formed from gelatinization during processing in food applications. It also reflects the extent of granule swelling (Liang and King, 2003) and could be indication of the viscous load likely to be encountered during mixing.

The highest value of the trough was recorded for 100% acha flour while the lowest value of the trough was recorded in 80% acha flour addition with 20% tangerine peel flour. They was a significant difference among the flour samples

Table 5 : Pasting Properties of Acha-Tangerine Peel Biscuit

Acha:Tangerine peel(%)	Peak Viscos(RUU) ity	Trough (RVU)	Breakdown viscosity (RUV)	Final viscosity (RVU)	Set back (RVU)	Peak time (Mins)	Pasting temperature (°C)
A	234.98±1.56^{f}	148.75±0.47^{f}	86.23±2.73^{f}	338.22±0.01^{a}	201.38±0.06^{a}	8.12±0.02^{e}	75.37±0.03^{e}
B	216.93±1.42^{e}	145.11±1.92^{e}	71.82±2.58^{e}	331.03±0.03^{a}	210.12±0.01^{b}	9.49±0.01^{f}	79.12±0.01^{f}
C	204.00±0.42^{d}	134.49±2.70^{d}	69.51±24.77^{d}	344.71±0.35^{b}	222.75±0.67^{c}	7.00±0.01^{d}	67.23±0.02^{d}
D	188.92±2.48^{c}	124.46±0.89^{c}	64.46±41.40^{c}	347.12±0.01^{c}	229.72±0.60^{d}	6.52±0.02^{c}	65.77±0.24^{c}
E	174.35±1.03^{b}	121.11±1.17^{b}	53.24±47.06^{b}	349.33±0.03^{d}	236.80±0.45^{e}	6.02±0.02^{b}	61.15±0.03^{b}
F	151.64±3.24^{a}	115.35±0.89^{a}	36.29±46.00^{a}	352.48±0.06^{e}	236.07±18.2^{e}	5.10±0.01^{a}	59.34±0.44^{a}

Values are presented as means ± SD. Values with different superscript within the same column are significantly different (p=0.05).
Key: *A = 100% WF, B =100% AF, C = 95% AF; 5% TF, D = 90% AF; 10% TF, E = 85% AF; 15% TF , F = 80% AF; 20% TF. Where AF = Acha Flour, WF = Wheat Flour and TF = Tangerine Peel Flour.*

with the increase in the level of tangerine peels (p = 0.05) which meant that the higher the quantity of tangerine peels added, the lesser the trough of the flour samples. Trough thickness measures the smallest capacity of the paste to resist collapse during the period of cooling (Adegunwa *et al.,* 2011).

The lowest value of the breakdown was recorded for 80% acha flour added with 20% tangerine peel flour while the highest value of the breakdown was recorded in 100% acha flour. The breakdown viscosity showed a significant difference among the flour samples with the addition of tangerine peels (p = 0.05) which meant that the higher the quantity of tangerine substituted, the higher the breakdown values of the flour samples. Breakdown viscosity reflects the stability of the paste during processing. The higher the breakdown in viscosity, the lower the ability of the starch in the flour samples to withstand heating and shear stress during (Adebowale *et al*., 2005). It was also reported by (Chinma *et al*., 2010) that high breakdown value indicates relative weakness of the swollen starch granules against hot shearing while low breakdown values indicate that the starch in question possesses cross-linking properties.

The highest value of the final viscosity and setback viscosity was recorded for 80% acha flour added with 20% tangerine peel flour while the lowest value was recorded in 100% wheat and acha flour respectively. The lower setback viscosities of acha starches could make it suitable for preparing gels with tendencies to synerese (Jideani and Akingbala, 1993) There were significant differences (p = 0.05) among the flour samples. The final viscosity and setback viscosity increased with an increase in addition of the tangerine peel flour. Final viscosities are important in determining ability of the flour sample to form a gel during processing while Set back viscosity indicates gel stability and potential for retrogradation. (Liang and King, 2003; Niba *et al*., 2001 and Chinma *et al*., 2010) also reported that high setback value is an indication of the propensity of the starch molecules to disperse in hot paste and re-associate readily during cooling.

Pasting time value ranged from 9.49 min to 5.10 min while pasting temperature value ranged from 79.12˚C to 59.34˚C. Pasting time is a measure of the cooking time (Adebowale *et al*., 2005). A higher pasting temperature indicates high water-binding capacity, higher gelatinization tendency and lower swelling property of starch-based flour due to high degree of associative forces between starch granules (Adebowale *et al*., 2005). Pasting temperature is one of the properties which provide an indication of the minimum temperature required for sample cooking, energy costs involved and other components stability. Therefore from the result obtained, 80:20% acha-tangerine peel samples could be said to cook faster with less energy consumption, thereby saving time and cost.

\Physical Properties of Acha-Tangerine Peel Flour Biscuit

The results of physical properties of acha-tangerine peel flour biscuit are presented in Table 6

Diameter showed a significant difference with increase in tangerine peel. Thickness ranged from 0.89mm (100% wheat flour) to 0.70mm (5% tangerine and 95% acha flour). The increase in thickness was not significantly different.

Acha flour biscuit exhibited spread ratio of 6.54 while biscuits containing tangerine peel flour exhibited a decrease in their spread ratio (6.70-5.57%) as the amount of tangerine peel in the blend increased. Okaka and Isieh (1990) reported similar trend in biscuits from wheat and cowpea flours.

The break strength of the biscuit blend (5-20%) increased from (2.52-3.00kg) with increase in the added tangerine peel flour. The increase was an indication of the binding properties of the flour blends and fibre. The result of the break strength agrees with the work of Okaka and Isieh (1990).

Table 6 : Physical Properties of Acha-Tangerine Peel Biscuit

Acha:Tangerine peel flour(%)	Diameter(cm)	Thickness(mm)	Spread ratio	Break strength(kg)
A	5.07 ± 0.18^{e}	0.89 ± 0.01^{b}	5.72 ± 0.14^{ab}	1.98 ± 0.08^{a}
B	5.18 ± 0.11^{f}	0.79 ± 0.04^{a}	6.54 ± 0.26^{d}	2.13 ± 0.06^{b}
C	4.69 ± 0.05^{d}	0.70 ± 0.03^{a}	6.70 ± 0.18^{e}	2.52 ± 0.03^{c}
D	4.47 ± 0.03^{c}	0.70 ± 0.01^{a}	6.41 ± 0.05^{c}	2.57 ± 0.06^{c}
E	4.31 ± 0.09^{b}	0.72 ± 0.04^{a}	5.98 ± 0.17^{b}	2.78 ± 0.03^{d}
F	4.17 ± 0.08^{a}	0.75 ± 0.00^{a}	5.57 ± 0.11^{a}	3.00 ± 0.00^{e}

Values are presented as means ± SD. Values with different superscript within the same column are significantly different (p=0.05).
Key: *A = 100% WF, B =100% AF, C = 95% AF; 5% TF, D = 90% AF; 10% TF, E = 85% AF; 15% TF , F = 80% AF; 20% TF. Where AF = Acha Flour, WF = Wheat Flour and TF = Tangerine Peel Flour.*

The increase in the break strength could be an advantage in reducing the rate of breakage of the biscuits during transportation from industry to the consumers. However, too high break strength could reduce the efficiency of digestion and possible absorption of the inherent nutrient.

Phytochemical Compositions of Acha Tangerine Peel Flour Biscuit

The results of phytochemical compositions of acha-tangerine peel flour biscuit are presented in Table 7. There was a significant difference ($p < 0.05$) in phenol content among biscuit samples. The trace quantities of phenolic

compounds indicate that the sample could act as immune enhancers, hormone modulators, antioxidant, anti-clothing and anti inflammatory (Okwu and Omodamoro, 2005)..

There was no significant difference ($p<0.05$) among the samples. Flavonoids are important antioxidants, and promote several health effects (Randine, 2003). Flavonoids have antioxidant properties that play protective role against the development of cardiovascular diseases, atherosclerosis, hypertension, ischemia/reperfusion injury, diabetes milletus, neurodegenerative diseases (Alzheimer's diseases and Parkinson's diseases), rheumatoid, arthritis and aging (Kris-Etherton *et al*., 2002).

Table 7: Phytochemical Composition of Acha-Tangerine Peel Biscuit

Acha:Tangerine peel flour(%)	Phenols (mg/100g)	Flavonoid (mg/100g)	Phytate (mg/100g)	Tannin (mg/100g)	Oxalate (mg/100g)	Saponin (mg/100g)
A	$0.88{\pm}0.01^{c}$	$0.14{\pm}0.06^{b}$	$0.34{\pm}0.01^{c}$	$0.92{\pm}0.01^{b}$	$0.00{\pm}0.00^{a}$	$1.06{\pm}0.01^{b}$
B	$2.68{\pm}0.01^{e}$	$0.82{\pm}0.01^{c}$	$1.63{\pm}0.01^{d}$	$0.86{\pm}0.01^{b}$	$2.23{\pm}0.01^{c}$	$2.95{\pm}0.01^{c}$
C	$0.64{\pm}0.01^{a}$	$0.05{\pm}0.00^{a}$	$0.19{\pm}0.02^{a}$	$0.19{\pm}0.02^{a}$	$0.87{\pm}0.03^{b}$	$0.01{\pm}0.00^{a}$
D	$0.75{\pm}0.01^{b}$	$0.06{\pm}0.01^{a}$	$0.20{\pm}0.01^{b}$	$0.21{\pm}0.01^{a}$	$0.87{\pm}0.02^{b}$	$0.02{\pm}0.01^{a}$
E	$0.86{\pm}0.02^{c}$	$0.06{\pm}0.01^{a}$	$0.21{\pm}0.02^{b}$	$0.23{\pm}0.01^{a}$	$0.87{\pm}0.20^{b}$	$0.01{\pm}0.00^{a}$
F	$1.24{\pm}0.03^{d}$	$0.08{\pm}0.00^{a}$	$0.22{\pm}0.03^{b}$	$0.24{\pm}0.12^{a}$	$0.86{\pm}0.03^{b}$	$0.01{\pm}0.00^{a}$

Values are presented as means ± SD. Values with different superscript within the same column are significantly different (p=0.05).
***Key:** A = 100% WF, B =100% AF, C = 95% AF; 5% TF, D = 90% AF; 10% TF, E = 85% AF; 15% TF , F = 80% AF; 20% TF. Where AF = Acha Flour, WF = Wheat Flour and TF = Tangerine Peel Flour.*

Phytates showed no significant difference with the increase in added tangerine peel flour. Phytates lower the blood glucose response of diabetes patients by reducing the rate of starch digestion and slowing gastric emptying, Gemede *et al.,* (2014).

Tannins are reported to exhibit anti-diuretic, anti-inflammatory and anti-bacterial, antiulcer, anti-diarrhea, antiviral and anti-tumor activities and also reported to be able to inhibit HIV replication selectively (Okwu & Okwu, 2004). Tannis decrease with ripening and hence reduce to amounts that are harmless to the body. It reduces respiratory problem and circulatory disorder like lowering blood pressure and reduction of cholesterol in blood (Cheeke, *et al.,* 2006). The total acceptable daily intake of tannin by man is 560mg. the result given above shows that tannin in the biscuit samples can be more beneficial than harmful, Gemede *et al.,* (2014).

Oxalate was completely absent in 100% wheat flour but relatively present in 100% acha flour. Oxalate decreased with addition of tangerine peels. The required level of oxalate in the body is 45mg/day as medically reviewed by Miho *et al.,* (2020).

Saponins composition ranged from 2.95mg/100g (100% acha flour) to 0.01mg/100g (5% tangerine peel and 95% acha flour). Saponins are relatively in samples containing tangerine peels (5-20%).

Sensory Evaluation of Acha-Tangerine Peel Flour Biscuit

The results of Sensory evaluation of acha-tangerine peel flour biscuit are presented in Table 8

The mean scores of appearance ranged from 8.40 of sample A (100% wheat flour) to 5.65 of sample F (20% tangerine peel and 80% acha flour). There was no significant difference (p>0.05) in sample containing 15% and 20% of tangerine peels.

The mean scores for taste ranged from 8.30 of sample A (100% wheat flour) to 3.50 of sample F (20% tangerine peel and 80% acha flour). There was a significant difference in samples containing 5%, 10%, 15% and 20% of tangerine peels.

The mean scores of texture ranged from 7.95 of sample A (100% wheat flour) to 5.10 of sample F (20% tangerine peel and 80% acha flour). Sample containing 10% tangerine peel had the highest score, the mean scores for texture of all the samples showed a significant difference (p=0.05).

Table 8: Sensory Properties of Acha-Tangerine Peel Biscuit

Acha:Tangerine peel flour(%)	Appearance	Taste	Texture	Flavor	Overall Acceptability
A	$8.40±0.68^{e}$	$8.30±0.66^{f}$	$7.95±1.05^{d}$	$8.15±0.88^{f}$	$8.53±0.62^{e}$
B	$7.95±1.10^{d}$	$7.50±1.32^{e}$	$6.95±1.61^{e}$	$7.65±1.09^{e}$	$7.76±1.09^{d}$
C	$6.80±1.54^{c}$	$5.85±1.69^{d}$	$5.40±1.90^{b}$	$6.15±1.50^{d}$	$5.94±1.48^{c}$
D	$6.10±2.08^{b}$	$5.05±1.85^{c}$	$5.75±2.02^{c}$	$5.70±2.00^{c}$	$5.59±2.09^{bc}$
E	$5.70±2.22^{a}$	$4.25±1.97^{b}$	$5.20±1.99^{ab}$	$4.90±2.25^{b}$	$5.12±2.29^{b}$
F	$5.65±2.56^{a}$	$3.50±1.93^{a}$	$5.10±2.36^{a}$	$4.25±2.49^{a}$	$4.41±2.27^{a}$

Values are presented as means ± SD. Values with different superscript within the same column are significantly different (p=0.05).
Key: *A = 100% WF, B =100% AF, C = 95% AF; 5% TF, D = 90% AF; 10% TF, E = 85% AF; 15% TF , F = 80% AF; 20% TF. Where AF = Acha Flour, WF = Wheat Flour and TF = Tangerine Peel Flour.*

The mean scores for flavour ranged from 8.15 of sample A (100% wheat flour) to 4.25 of sample F (20% tangerine peel and 80% acha flour). There was a significant difference (p<0.05) in samples containing tangerine peels as well as 100% wheat and 100% acha.

The mean score for the overall acceptability ranged from 8.53 of sample A (100% wheat flour) to 4.41 of sample F (20% tangerine peel and 80% acha flour). Appearance, taste, texture and flavor decreased from 6.80 - 5.65%, 5.85 - 3.50%, 5.40 3.10% and 6.15 4.25%, respectively with the addition of tangerine peels (5-20%). The decrease was generally significant (p<0.05). The relatively low average means score in the taste above 10% added tangerine peel could be due to the inherent bitter compound albedo in the peel. The blend biscuit was generally accepted up to 15% level of added tangerine peel flour, but most preferred of 5% level. The scores for general acceptability decreased significantly (p < 0.05) from 7.76 in the biscuit produced from 100% acha flour to the ranged of 5.94 to 4.41 for the biscuit containing tangerine peel flour. Akpata and Akubor *et al.,* (2000) reported similar work in bread production, that increase in orange peel decreased the taste from 8.2-4.4 and texture from 8.6-6.8 respectively.

CONCLUSION

The result of this study showed that addition of tangerine peel flour improved the functional properties, fibre, ash, minerals and vitamins content.

The acha-tangerine flour blend biscuits was generally accepted up to 15% , however the 95:5% acha-tangerine peel blends was the most preferred. There were also corresponding improvement in the fibre content and minerals of the blend biscuits. The break strength which directly determines the texture of the biscuit was improved. The acceptability of tangerine peel - acha flour blend biscuit could be said to have added variety to diabetes meals and other individuals that are non- tolerant to gluten. The result shows that there is an ample opportunity for the use of tangerine peel in various food products also.

REFERENCES

Abara (2011). Proximate and Mineral Elements Composition of the Tissue and Peel of Dioscorea Bulbifera Tuber. Pakistan Journal of Nutrition, 10: 543-551. DOI:

Adeleke, R.O. and Odedeji J.O. (2010). Functional properties of wheat and sweet potato flour blends. Journal Nutrition 9(6): 535-538.

Adegunwa, M. O , Adebowale, A. A, Bakare, H.A and Ovie , S. G (2014). Compositional characteristics and functional properties of instant plantain breadfruit flour Int. J. Food Res pg 1-7.

Alamu (2001) The Effect of Cooking on Proteins from Acha (Digitariaexilis) and Durum Wheat. J Sci Food Agric 65(4): 465-476.

AOAC(2000). Official Methods of (A.O.A.C) Analysis of association 18th edition of official analytical chemists, Washington DC.

Akubor, P.I. and Eze, J.I. (2012). Quality evaluation and cake making potential of sun and oven dried carrot fruit. International Journal of Bioscience 2 (10): 19 -27.

Ayo, J.A. and Kajo N. (2016). Effect of Soybean Hulls Supplementation on the Quality of Acha Based Biscuits.

Ayo, J.A. and Nkama I. (2003). Effects of Acha (Digitaria exilis Staph) Grain Flour on the Physical Sensory Quality of Biscuit. Journal of Nutrition and Food Science 33(3): 125-135.

Cheeke PR, Piacente S, Oleszek W (2006). Anti - inflammatory and anti - arthritic effects of Yucca Schidigera: A review. J. Inflam 3: 1 -7

Chinma, C.E., Abu, J.O. and Ojo, J.A. (2010) Chemical, Functional and Pasting Properties of Starches from Brown andYellow Tigernuts (Cyperus esculentus). Nigerian Food Journal, 28, 1-13.s

Cho, E.,Seddon, J.M., Rosner, B.,Willett, W.C. and Hankinson, S.E. (20014). Prospectivemaculopathy Arch Ophthalmol. African Journal of Food Science 8: 77-79.

Dewey K. Nutrition, growth, and complementary feeding of the breastfed infant. Pediatric Clinics of North. America 2001; 48(1): 87-104.

Emmanuel- Ikpeme C, Ekpeyoung I.O and G. O. Igile G.O (2012).Nutritional and Sensory Characteristics of an Infant Food Based on Soybean Seeds (Glycine max) and Tigernut Tubers (Cyperus esculenta) British Journal of Applied Science & Technology 2(4): 356-366, 2012

Giami, S.Y., Amasisi, T. and Ekiyor, G. (1992). Comparison of Bread Making Properties of Composite Flour from Kernels of Toasted and Boiled African Bread fruit (Treculia africandecne) seeds.Journal of Raw Materials Research, 1(1), 16 -25.

Gomez, Thomas M, Motarjemi, Yasmine, Miyagawa, Shoji, Kaferstein, Fritz K & Stöhr, Klaus.)1997(. Foodborne salmonellosis , World health statistics quarterly 50)1/2(: 81-89

Habtamu Fekadu Gemede, Negussie Ratta, Gulelat Desse Haki & A s hagrie Z. (2014). Nutritional Quality and Health Benefits of Okra (A belmoschus Esculentus) .Global Journal of Medical Research: K I nerdisciplinary Volume 14 (5): 28-39

Harborne, J. B. (1973). Phytochemical methods: A guide to modern techniques of plant analysis.Chapman and Hall Ltd, London.; Pp.279.

Hussein, H.M, Hussein. M.M, El-Damohery. S.T. (2006). The effect of natural formulated functional biscuits on an elderly bone health. Journal of Medical. Science. 6:937-943.

Ibrahim, M (2012). Proximate and Amino Acid Compositions of Wheat Species of Pigeon Pea Grown in Kogi State, Nigeria. Nigerian Journal of Biochemistry and Molecular Biology 24 (2), 32-36

Ifesan, B Adebowale A.A.Sanni L. O. & Awonorin S. O. (2005). Effect of texture modifiers on the physicochemical and sensory properties of dried fufu. Food Sci. Technol Int .11(5):373-382

Iwe, M.O. (2002) Handbook of Sensory Methods and Analysis. Rojoint Publishers, Enugu, 78-82.

Iwe, M. O. and Onadipe, O. O. 2001. Effect of extruded full fat soy flour into sweet potato

flour
on functional properties of the mixture. Journal of Sustainable Agriculture and Environment 3(1):109-117.

Jideani A.I. and Akingbala, J.O. (1993).Some Physiochemical Properties of Acha (DigitariaexilisStaph) and Ibuns (DigitariainuniaStaph) Grains. Journal of Food

Jideani, I.A. (1990). Acha Digitaria exilis the Neglected Cereal. Agric Int 42(132134):143.

Jideani, I.A., OwusuApenten, R.K. and Muller, H.G. (1994). The Effect of Cooking on Proteins from Acha (Digitariaexilis) and Durum Wheat. J. Sci. Food Agric 65:465476.

Kahlon T.S (2009). Evaluating Healthful Properties of Cereals and Cereal Fractions by their Bile-Acid-Binding Potential. Cereal Foods World. 54:118121.

Kasarda D.D. (2001). Grains in Relation to Celiac Disease. Cereal Foods World, 46:209-210.

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.

Lasekan, O.O. (1994.) Chemical Composition of"Acha" flour. Nigeria Food Journal 12:19-23.

Li, M. H. ;Robinson, E. H., 2006. Use of cottonseed meal in aquatic animal diets: a review. North Am. J. Aquaculture, 68 (1): 14-22

Liang, X. and King, J.M. (2003) Pasting and Crystalline Property Differences of Commercial and Isolated Rice Starch with Added Amino Acids. Journal of Food Science, 68:832-838.

Liu, F.O. and Chang, S.T. (1995). Antitumor Components of Culture Filtrates from Tricholoma sp. World Journal Microbiology Biotechnology, 11:486-490.

Lumen B.O., Thompson S. and Odegard J.W. (1993). Sulphur Amino Acid-Rich Proteins in Acha (Digitaria Exilis), A Promising Underutilized African Cereal. J. Agric. Food Chem. 41:1045-1047.

Morales-Payan J.P., Ortiz J.R., Cicero J. and Taveras F. (2002). Digiteria exilis as a Crop in the Dominican Republic. In: Janick J, Whipkey A, Editors. Supplement to: Trends in New Crops and New Uses. Alexandra: ASHS Press.

National Research Council (1996). "Fonio (Acha)". Lost Crops of Africa: Volume I: Grains. Lost Crops of Africa. 1. National Academies Press.page=59. Retrieved 2008-07-18.

Niba, L.L., Bokanga, M.M., Jackson, F.L., Schlimmme, D.S. and Li, B.W. (2001) Physicochemical Properties and Starch Granular Characteristics of Flour from Various Manihot esculenta (Cassava) Genotypes. Journal of Food Science, 67:20-24.

Nzelibe H.C., Obaleye S. and Onyenekwe P.C. (2000). Malting Characteristics of Different Varieties of Fonio Millet (Digitaria Exilis). Eur. Food Res. Technol. 211:126-129.

Obizoba I.C. and Anyika J.U. (1994). Nutritive Value of Baobab Milk (Gubdi) and Mixtures of Baobab (Adanosonia Digitata L.) and Hungry Rice, Acha (Digitaria Exilis) Flours. Plant Food Hum Nutr. 46: 157-165.

Okafor, J.N., Okafor, G.I., Ozumba, A.U. and Elemo, G.N. (2012). Quality Characteristic of Bread Made From Wheat and Nigerian Oyster Mushroom (Pleurotus ostreatus) Powder. Pakistan Journal of Nutrition. 11(1):5-10

Okafor, G. I. and Ugwu, F.C. (2014). Production and evaluation of cold extruded and baked ready-to-eat snacks from blends of breadfruit (Treculia africana), cashewnut (Anacardium occidentale)and coconut (Cocos nucifera). Food Science and Quality Management. , 23:65-77

Okaka, J.C. and Isieh, M.I. (1990). Development and Quality Evaluation of Cowpea-Wheat Biscuits. Nigerian Food Journal. 1990, 8:56-62.

Okaka, J.C. (2005). Handling, Storage and Processing of Plant Foods. Ocjanco Academic Publishers, Enugu, Nigeria. Pp. 162 172.

Okeagu, N.J. (2001). Extraction and Comparison of the two Varieties of Beniseed Oil (Project Submitted to the Department of Food Science and Technology, Federal Polytechnic, .Bauchi) Pp. 15.

Okwu, D.E. and Omodamiro, O.D. (2005). Effects of Hexane Extract and

Phytochemical Content of Xylopiaaethiopila and Ocimumgratissimum on the Uterus of Guinea Pig. Biological Research, 4(2): 45-51.

Omoba O.S, Obafaye R.O, Salawu S.O, Boligon A.A.,and Athayde , M.L (2015). HPLC DAD Phenolic Characterization and Antioxidant Activities of Ripe and Unripe Sweet Orange Peels Antioxidants 4, 498-512;

Onimawo, I. A, and Akubor, P. I. (2012). Food Chemistry (Integrated Approach with Biochemical background) (2nd ed.). Ibadan, Nigeria: Joytal Prints.Pp. 45-56.

Onwuka, G.I. (2005). Food Analysis and Instrumentation: Theory and Practice. Nigeria: Naphathali Prints. pp 95-96

.Randine RL (2003). Immunologic, Autoimmune Factors and Recurrent Miscarriages wwweasternharmonyclinic.com

Salem, F.A., Nefisa, A., Hegazy, Somaya, M., Abd El-Moneim, A.R., Shalaby, and Hussein, A.M. (1999). Evaluation of Egyptian Corn Varieties for Tortilla Bread Production. Proc. 6th Arabic Conference on Food Science and Technology, Cairo Egypt, 334-352.

Sanni, S.A., Adebowale, A.R., Olayiwola, I.O. and Maziya-Dixon, B. (2008). Chemical Composition and Pasting Properties of Iron Fortified Maize Flour. J. Food, Agric. Environ, 6: 172-175.

Singh, K.K., Samanta, A.K. and Maity, S.B. (2001). Nutritional Evaluation of Stylo (Stylosanthes Hamata) Hay in Goats. Indian J. Anim. Nutr, 18(1):96-98.

Sofowora, E.A. (1982) Medicinal Plants and Traditional Medicine in Africa. John Wiley and Sons Ltd., Hoboken, 64-79.

Storggard. (2008). Mitochondrial Function in Skeletal Muscle is Normal and Unrelated to Insulin Action in Young Men Born with Low Birth Weight. Journal of Clinical Endocrinology and Metabolism, 93(10):3885-92.

Temple, V.J. and Bassa, J.D. (1991). Proximate Chemical Composition of Acha (D. Exilis) Grain. J Sci. Food Agric. 56:561563.

Trease, G.E. and W.C. Evans, 1989. Pharmacognosy 2ndEdn, Braille Tiridel and Macmillanpublishers

Wardlaw, G.M. (2004). Perspectives in Nutrition (6th ed.). McGram Hill Companies, New York, U.S.A.90