Chemical and Sensory Properties of Stiff Dough Produced from Blends of Water Yam and Black Bean Flours

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ABSTRACT

This research aims to make stiff dough from water yam and black turtle bean (Akidi) flours and ascertain the quality attributes. The water yam was peeled, sliced while in water, oven dried at 60℃ for 4 h and milled into flour while the black bean was sorted, divided into two equal parts one part was soaked for 5 h while the other was boiled for10 mins and thereafter oven dried at 65 ℃, dehulled and milled into flour. The flour samples were blended at different ratios of water yam to black turtle bean, 100 % water yam flour (WY) served as control, 90:10 (WB1), 80:20 (WB2), 70:30 (WB3), 60:40 (WB4), 50:50 (WB5), 90:10 (WS1), 80:20 (WS2), 70:30 (WS3), 60:40 (WS4) and 50:50 (WS5). The proximate, anti-nutritional and consumer acceptability were assessed. The nutritional compositions of the product all showed significant differences. The flours' proximate composition revealed the following ranges of results: 1.84 to 5.20% ash, 0.61 to 1.87% crude fat, 0.72 to 2.17% crude fibre, 2.57 to 8.17% moisture, and 71.35 to 81.95% carbohydrate. The antinutritional compositions showed that boiling reduced the phytate and tannin contents to 0.05 mg/100g and 0.06 mg/100g while soaking caused a significant reduction ($p<0.05$) in the saponin and oxalate contents to 0.06 mg/100g and 0.02 mg/100g respectively. Stiff dough prepared from soaked sample WS1(90:10) had the highest overall acceptability. These findings suggests that water yam/black turtle stiff dough can meet the nutritional demands of the populace. This study provides an alternative way of utilizing water yam and black turtle bean thus preventing post-harvest losses and ensuring eradication of protein energy malnutrition and proper food security.

INTRODUCTION

The economic condition in Nigeria and other developing nations is such that low-income families cannot afford the recommended daily ration of animal protein. According to Onwuka and Ihuma (2007) over a billion people suffer from undernourishment. Legume and tuber crop fortification or enrichment can help reduce the worldwide malnutrition (Hoover, 2001). Water-yam (*Dioscorea alata*), also referred to as greater yam (majorly cylindrical in shape), or Ji Abana in Igbo, is known for its high nutritional content, with crude protein content of 7.4%, starch (75 - 84%) and vitamin C content ranging from 13.0 to 24.7 mg/100g (Dauda *et al*., 2022).

In general, they have a longer shelf life and less sugar, which guarantees availability during times of scarcity. Varieties of *D. alata* are also excellent providers of zinc, which lowers blood pressure in people. According to Bhandari *et al*. (2013), water yams are an excellent source of potassium, which is necessary for healthy kidney function and blood pressure regulation. Thus, those with high blood pressure may benefit from eating water yam. Black turtle beans (*Phaseolus vulgaris*) also known as "Akidi oji" in Igbo (Odo, 2010). The seeds can be processed to make a variety of goods, including flour, starch, protein isolates, concentrates, and extruded foods. Although very nutritious, Nigerians rarely use black turtle beans. It has long been known that beans are an excellent source of dietary fiber, minerals (P, K, Ca, and Mg), vitamins (thiamine and niacin), and plant protein. Minerals like calcium, iron, copper, zinc, potassium, phosphorus, and magnesium are abundant in black beans (Siddiq and Uebersax, 2013). On the other hand, some anti-nutritional components found in legumes include tannins, protease inhibitors, trypsin and phytic acid must be reduced or eliminated in order to avoid poisoning from these anti-nutrients. Water yam as an underutilized food product with high moisture content, can be processed into flour and appropriately fortified with black turtle bean flour to create composite flour which can be reconstituted with boiling water to form a stiff-dough. According to Oyango (2014), stiff dough is a food prepared from flour that is stirred continuously in boiling water to obtain a homogenized gelatinous mixture without lumps. The incorporation of black turtle bean to water yam will improve the nutritional quality of the stiff dough as well help combat protein-energy malnutrition in the general population and provide the necessary nutrients for proper body metabolism when compared to pounded yam only.

MATERIAL AND METHODS

Raw materials: Black turtle beans (*Phaseolus vugaris*) and water yam (*Dioscorea alata*) were bought from Ogige market in Nsukka, Enugu state Nigeria.

Experimental Design: Experimental design used was completely randomized design.

Table 1: Experimental Design

S/N	Sample Code	Soaked Black Turtle Beans Flour	Boiled Black Turtle Beans Flour	Water Yam Flour
1.	WY	0.00	0.00	100.00
2.	WB1	0.00	10.00	90.00
3.	WB2	10.00	0.00	90.00
4.	WB3	0.00	20.00	80.00
5.	WB4	20.00	0.00	80.00
6.	WB5	0.00	30.00	70.00
7.	WS1	30.00	0.00	70.00
8.	WS2	0.00	40.00	60.00
9.	WS3	40.00	0.00	60.00
10.	WS4	0.00	50.00	50.00
11.	WS5	50.00	0.00	50.00

Production of Water Yam Flour

With few adjustments, the approach outlined by Babajide *et al.* (2006) was employed. Five kilograms of water yam tubers were cleaned to get rid of extra dirt and sand, they were peeled with a sanitized kitchen knife, immersed in potable water, and cut to a thickness of two millimeters while still submerged in water to prevent browning. After they were oven dried for four hours at 60°C, the sliced water yam was ground into powder using a Qasa high power blender and grinder (Model: QBL-8008 PR), and the resulting fine flour was sieved through an 80mesh screen. After being carefully packed and sealed in an airtight container, the water yam flour was kept for later examination.

Processing of Soaked and Boiled Black Turtle Bean Flours

Black turtle bean seeds (*Phaseolus vulgaris*) were prepared according to the method described by Okafor *et al.* (2015). A measure weight (3 kg) of black turtle beans were manually sorted to remove physical impurities, cleaned with potable water to get rid of dust, dirt, and other sticking impurities. The cleaned beans were then split into two parts one part was soaked for five hours in potable water and the other part boiled for ten minutes at 100°C and finally oven (Model: HS206A) dried for five hours at 65°C. In order to obtain bean flours, they were dehulled, milled using a Qasa high power blender (Model: QBL-8008PR) and sieved through an 80 mm mesh screen. Samples of flour were stored in an airtight container until when needed for analysis.

Preparation of stiff dough from composite flour

The method described by Karim *et al.* (2013) was adopted. The stiff dough was formed by mixing the blended flour samples in boiling water, which was allowed to boil at 100°C for 3 minutes, the blended flour samples were poured into the boiling water and mixed manually using a stirrer until a smooth dough was formed, then a little water was added to cook properly for 1 minute and the stiff dough was ready.

Determination of Proximate Composition and Anti-Nutrients:

The proximate composition of flour samples was determined using methods described by AOAC (2010), tannin, saponin and oxalate contents were determined using the method of AOAC, (2010) while phytate was determined using methods described by Hangh and Lantzscl (1993).

Sensory Evaluation:

The method described by Iwe *et al*. (2014) was adopted for the sensory evaluation. 25-man semi-trained panelists evaluated the quality of the formulated stiff dough and accessed the samples on a 9-point Hedonic scale for taste, colour, texture, aroma, and overall acceptability, with 9 representing strongly like and 1 representing extremely dislike.

Statistical Analysis: The Statistical Package for Social Science (SPSS) version 23.0 software was used to analyze the generated data. Duncans New Multiple Range Test (DNMRT) was used to separate and detect significant differences ($p<0.05$) among means using Analysis of Variance (ANOVA) and Least Significant Difference (LSD).

RESULTS AND DISCUSSION

Proximate composition of instant flours produced from water yam and black turtle bean.

Table 3 displays the findings of the flour samples' proximate compositions. The flour samples had moisture contents ranging from 2.57 to 8.00 %. Sample WB1(90:10 – water yam:boiled black Turtle Bean), had the highest moisture content (8.20 %), whereas sample WS5 (50:50 - water yam:boiled black Turtle Bean), had the lowest moisture content (2.57 %). There were notable variations ($p<0.05$) between the boiled and soaked samples' moisture contents. The moisture content of the sample flours increased significantly after boiling at 100°C for 10 minutes. This phenomenon may have been produced by the protein molecules' heat-denaturation, which allowed them to absorb moisture from the surrounding medium. This low moisture content indicates that the flour samples won't be susceptible to microbial deterioration and will be shelf stable in storage settings.

The flour samples' ash contents varied from 0.72 to 2.17%. There were significant variations ($p<0.05$) between the samples, but not between soaked samples WS3 (70:30) and WS4 (60:40) for their ash contents of 2.07% and 2.05% percent respectively. It was shown that soaking marginally increased the ash level of the flour samples, whereas boiling greatly decreased the ash content. The amount of ash in a sample indicates the mineral salts present. These samples' high ash content indicates that they will have a high mineral content. These results are lower than the values of 4.87 - 4.98 % obtained by Dauda *et al.* (2022) for white, water, and cocoyam flour, but they are higher than 0.50 - 2.53 % obtained by Odoh *et al.* (2022) for fufu composite flours.

Significant variations ($p<0.05$) were observed in the fat content of the flour samples, which varied between 0.61 and 1.86 %. Sample WS5(50:50- water yam: soaked black turtle bean), had the least value of 0.61 % while sample WY (100% water yam) had the highest fat content of 1.86 %. These values are in agreement with the result (0.60 to 2.18 %) obtained by Bolaji *et al.* (2021) for fermented cassava flour (lafun) and pigeon pea flour.

Table 2: Proximate Composition of Instant Flour Blends from Water Yam and Black Turtle Beans

S/N	Samples	Moisture (%)	Ash (%)	Fat (%)	Fibre (%)	Crude Protein (%)	Carbohydrate (%)
1	WY	$5.40^{e}\pm 0.17$	$2.17^{a}\pm 0.02$	$1.87^{a}\pm 0.03$	$5.20^{a}\pm 0.10$	$5.50^{l}\pm 0.10$	$79.86^{c}\pm 0.00$
2	WB1	$8.17^{a}\pm 0.25$	$0.87^{g}\pm 0.02$	$1.53^{e}\pm 0.01$	$2.00^{f}\pm 0.02$	$8.12^{k}\pm 0.03$	$81.68^{a}\pm 0.00$
3	WB2	$5.23^{f}\pm 0.03$	$1.96^{d}\pm 0.02$	$1.64^{d}\pm 0.02$	$4.91^{c}\pm 0.03$	$10.73^{g}\pm 0.15$	$75.77^{f}\pm 0.00$
4	WB3	$7.61^{d}\pm 0.04$	$0.72^{j}\pm 0.01$	$1.72^{c}\pm 0.03$	$1.85^{h}\pm 0.05$	$14.95^{d}\pm 0.03$	$73.15^{g}\pm 0.00$
5	WB4	$7.78^{c}\pm 0.02$	$0.76^{i}\pm 0.02$	$1.79^{b}\pm 0.02$	$1.84^{h}\pm 0.02$	$15.94^{c}\pm 0.03$	$71.87^{h}\pm 0.00$
6	WB5	$3.15^{h}\pm 0.03$	$1.77^{e}\pm 0.02$	$0.62^{f}\pm 0.02$	$4.36^{d}\pm 0.02$	$16.05^{bcd}\pm 0.02$	$71.35^{h}\pm 0.00$
7	WS1	$7.82^{bc}\pm 0.02$	$0.82^{h}\pm 0.02$	$1.86^{a}\pm 0.02$	$1.93^{g}\pm 0.03$	$8.90^{j}\pm 0.03$	$81.95^{a}\pm 0.00$
8	WS2	$5.23^{f}\pm 0.03$	$1.96^{d}\pm 0.02$	$1.64^{d}\pm 0.02$	$4.91^{c}\pm 0.02$	$10.73^{g}\pm 0.15$	$77.05^{d}\pm 0.00$
9	WS3	$5.33^{ef}\pm 0.01$	$2.07^{c}\pm 0.02$	$1.71^{c}\pm 0.02$	$4.94^{c}\pm 0.02$	$9.50^{i}\pm 0.10$	$76.63^{e}\pm 0.00$
10	WS4	$5.31^{ef}\pm 0.01$	$2.05^{c}\pm 0.02$	$1.67^{d}\pm 0.03$	$4.93^{c}\pm 0.03$	$12.06^{f}\pm 0.20$	$75.77^{f}\pm 0.00$
11	WS5	$2.57^{i}\pm 0.04$	$0.93^{f}\pm 0.01$	$0.61^{f}\pm 0.02$	$2.15^{e}\pm 0.02$	$14.14^{e}\pm 0.04$	$73.44^{g}\pm 0.00$

Valus are Mean ± standard deviations of three (3) replicate. Data in the same column bearing different superscripts, differ significantly ($p<0.05$).

KEY: WY: Whole Water Yam Flour (100 %); WB1: (90:10): Water Yam + Boiled Black Turtle Bean Flour; WB2: (80:20): Water Yam + Boiled Black Turtle Bean Flour; WB3: (70:30): Water Yam + Boiled Black Turtle Bean Flour; WB4: (60:40) Water Yam + Boiled Black Turtle Bean Flour; WB5: (50:50) Water Yam + Boiled Black Turtle Bean Flour; WS1: (90:10): Water Yam + Soaked Black Turtle Bean Flour; WS2: (80:20): Water Yam + Soaked Black Turtle Bean Flour; WS3: (70:30) Water Yam + Soaked Black Turtle Bean Flour; WS4: (60:40) Water Yam + Soaked Black Turtle Bean Flour; WS5: (50:50) water yam + soaked black turtle flour.

and Dauda *et al*. (2022) for water yam and soybean flours,

The crude fiber content varied from 1.83 to 5.20 %. There were significant differences ($p<0.05$) between the samples. The high heat treatment during boiling resulted in a noticeable drop (1.84 %) in the samples' fiber content, whilst soaking produced a discernible increase (4.94 %) in same. This may be due to the fact that high thermal processes soften the fibre content (soluble and insoluble fibres) of foods which must have resulted to this decrease in fibre while soaking has less permissible strength. These results were greater than the values of Olapade *et al.* (2014) for fufu flours and Dauda *et al.* (2022) for white yam and cocoyam flours, which were 2.37 to 2.44 % and 0.14 to 1.42 %, respectively.

The percentages of protein varied between 5.50 and 16.56 %. Control Sample WY (100% water yam), had the lowest value of 5.20 %, while sample WB5(50:50- water yam: boiled black turtle bean), had the highest value of 16.50 %. Significant variations ($p<0.05$) were seen in the protein composition of the flour samples. The findings demonstrated that when the amount of black turtle beans in the flour blends increased, so did their protein level. This may be explained by the fact that 100% yam flour has a lower protein level (5.50%) than black turtle bean (16.05%). These values are greater than the values of 7.80–8.30 % for white yam and coco yam flours reported by Dauda *et al.* (2022) and 2.40 to 11.16 % for fufu composite flours reported by Odoh *et al*. (2022).

The carbohydrate values ranged from 71.35 to 81.95 %, with sample WB5 (50:50-water yam: boiled black turtle bean) having the lowest value of 71.35 %, which may have decreased due to decreased inclusion of water yam, and sample WS1 (90:10-water yam: black turtle bean) having the highest value of 81.95 % which may be attributed to the high ration of water yam in the flour sample. There were notable variations ($p<0.05$) between the samples. This outcome demonstrated that as the ratio of the water yam decreased the carbohydrate content of the sample increased with an increase in black turtle bean.

Anti-nutritional composition of instant flours produced from water yam and black turtle bean:

Table 3 shows the anti-nutritional composition of stiff dough flour blends from water yam and black turtle bean. The tannin content of the flour samples varied from 0.06 to 0.94 mg/100g. Samples WB1 (90:10- water yam:boiled black turtle bean) had the highest value while sample WB5(50:50) had the lowest value. The outcome demonstrates that the high concentration of water yam in the flour samples raised the degree of tannin content. These values compared well with the values 0.00 to 1.65 mg/100g obtained by Olaposi *et al.* (2017) for soaked and boiled Bambara groundnut cultivars. The significant reductions in tannins may be due to the removal of the seed coat from the legumes and leaching of tannins into the water. Mazahib *et al.* (2013) stated that soaking reduced the tannin content of cowpea, African yam beans, Bambara nut to non-detectable levels. Kalu *et al.* (2019) asserted that phenolics and tannins are water soluble and can be removed by soaking together with boiling.

The saponin contents varied from 0.06 to 0.98 mg/100g. The control sample WY (100 % water yam), had the highest 0.98 mg/100g while sample WS1 (90:10- water yam: soaked black turtle bean) had the lowest value of 0.06 mg/100g. The significant reduction in saponin may be due to the removal of the legume seed coat and the leaching of saponin into the soaking water. The saponin content obtained in this study were lower than the values 3.04 to 9.10 mg/100g reported by Olaposi *et al.* (2017) for newly developed Bambara groundnut cultivars after soaking for 0, 12, 24, 48 h and 1.37 mg/100g reported by

Table 3: Anti-Nutritional Composition of Flour from blends of Water Yam and Black Turtle Bean Flour (mg/100g)

S/N	Samples	Tannin	Saponin	Phytate	Oxalate
1	WY	$0.87^a \pm 0.02$	$0.98^a \pm 0.02$	$0.77^a \pm 0.01$	$0.87^a \pm 0.03$
2	WB1	$0.94^d \pm 0.01$	$0.71^b \pm 0.02$	$0.69^c \pm 0.01$	$0.56^c \pm 0.02$
3	WB2	$0.76^c \pm 0.01$	$0.79^c \pm 0.02$	$0.72^b \pm 0.00$	$0.68^b \pm 0.02$
4	WB3	$0.07^d \pm 0.00$	$0.63^d \pm 0.02$	$0.06^d \pm 0.05$	$0.04^f \pm 0.00$
5	WB4	$0.85^b \pm 0.03$	$0.63^d \pm 0.02$	$0.06^g \pm 0.00$	$0.09^d \pm 0.00$
6	WB5	$0.06^d \pm 0.00$	$0.07^g \pm 0.00$	$0.05^h \pm 0.02$	$0.04^f \pm 0.00$
7	WS1	$0.91^a \pm 0.05$	$0.06^f \pm 0.02$	$0.06^g \pm 0.00$	$0.02^h \pm 0.00$
8	WS2	$0.07^d \pm 0.00$	$0.07^g \pm 0.04$	$0.07^g \pm 0.05$	$0.03^g \pm 0.00$
9	WS3	$0.08^d \pm 0.00$	$0.08^e \pm 0.00$	$0.07^g \pm 0.00$	$0.03^g \pm 0.02$
10	WS4	$0.79^c \pm 0.00$	$0.08^e \pm 0.01$	$0.07^g \pm 0.04$	$0.04^f \pm 0.01$
11	WS5	$0.07^d \pm 0.06$	$0.71^b \pm 0.02$	$0.07^g \pm 0.00$	$0.05^e \pm 0.00$

Mean ± standard deviations of three (3) replicate. Data in the same column bearing different superscripts, different significantly ($p<0.05\%$).

KEY: WY: Whole Water Yam Flour (100 %); WB1: (90:10): Water Yam + Boiled Black Turtle Bean Flour; WB2: (80:20): Water Yam + Boiled Black Turtle Bean Flour; WB3: (70:30): Water Yam + Boiled Black Turtle Bean Flour; WB4: (60:40) Water Yam + Boiled Black Turtle Bean Flour; WB5: (50:50) Water Yam + Boiled Black Turtle Bean Flour; WS1: (90:10): Water Yam + Soaked Black Turtle Bean Flour; WS2: (80:20): Water Yam + Soaked Black Turtle Bean Flour; WS3: (70:30) Water Yam + Soaked Black Turtle Bean Flour; WS4: (60:40) Water Yam + Soaked Black Turtle Bean Flour; WS5: (50:50) water yam + soaked black turtle flour.

Mbagwu *et al*. (2011) for Bambara groundnut after soaking for 48 h.

The range of phytates was 0.05 to 0.77 mg/100g. The lowest level (0.05 mg/100g) was found in boiled sample WB5 (50:50), while the highest (0.77 mg/100g) was found in sample WY (100 percent water yam). Phytic acid frequently forms complexations with salts and minerals, it is possible that some of these compounds seeped into the soaking and boiling solutions, contributing to the decrease in the phytate concentration of the flour samples. These results are lower than the values of 365 to 813 mg/100g reported by Olaposi *et al.* (2017) for newly developed Bambara groundnut cultivar flours. Soaking which caused a significant reduction of phytate agreed with the result of Udensi *et al.* (2008) who reported phytate level of 0.387 to 0.097 after 24 h soaking.

The range of oxalate was 0.87 to 0.02 mg/100g. The highest amount of oxalate (0.87 mg/100g) was observed in sample WY (100 percent water yam) while sample WS1 (90:10), which was soaked, had the lowest content of 0.02 mg/100g. Soaking significantly reduced the oxalate content of the samples than boiling. This decrease might be the consequence of soluble oxalate salts seeping into the soaking and boiling media.

Sensory evaluation of stiff dough produced from blends of water yam and black turtle bean

The consumer acceptance of stiff dough made from mixtures of black turtle beans and water yam is shown in Table 4. Significant variations ($p<0.05$) were observed in every sensory parameter assessed. The sensory score for appearance ranged from 4 to 8. Sample WB1 (90:10- water yam: boiled black turtle bean) had the lowest value of 4.0 whereas sample WY (100 percent water yam) had the highest score of 8.0. Colour ranged from 4.0 to 8.0. Control sample WY (100% water yam) had the highest. This was followed by soaked sample WS1(90:10) with 7.0 while boiled sample WB1(90:10) had the lowest score of 4.0. Texture was rated on the basis of roughness/smoothness and ranged from 6.0 to 7.0. The control sample WY, boiled sample WB2(80:20), soaked sample WS2(80:20) and soaked sample WS4(60:40) had the highest scores 7.0, while the rest of the samples did not differ significantly ($p>0.05$). The texture decreased with increased inclusion of black turtle bean. The mouldability scores ranged from 4.0 to 7.0. The control sample (100 % water yam) and the boiled sample WB1 (90:10) received the highest ratings (7.0), whereas the boiled sample WB5 (50:50) received the lowest ratings. Thus, the higher the legume the lesser the mouldability. Taste ranged from 3.0 to 8.0. Significant variations existed. The sensory scores for aftertaste varied from 3.0 to 7.0. Sample WY (100 % water yam) had the highest value of 7.0, while sample WS4 (60:40) had the lowest value of 3.0. The overall acceptability of the stiff dough samples ranged from 5.0 to 8.0. The control sample WY (100 % water yam) was the most preferred by the consumers followed by soaked sample WS1 (90:10) while boiled sample WB1 (90:10) was rated the lowest score of 5.0.

Table 4: Sensory Evaluation of Stiff Dough Produced from Blends of Water Yam and Black Turtle Bean Flours

S/N	Sample Code	Appearance	Colour	Texture (roughness andsmooth-ness)	Moulda-bility	Taste	After taste	Mouthfeel	Overall acceptab-ility
1	WY	$8^{a}\pm 0.73$	$8^{a}\pm 0.85$	$7^{a}\pm 1.05$	$7^{b}\pm 0.65$	$8^{a}\pm 0.65$	$7^{a}\pm 0.82$	$7^{a}\pm 0.92$	$8^{a}\pm 0.79$
2	WB1	$4^{e}\pm 1.26$	$4^{e}\pm 1.37$	$6^{ab}\pm 1.80$	$7^{a}\pm 1.01$	$3^{h}\pm 1.21$	$3^{i}\pm 1.27$	$4^{g}\pm 1.72$	$5^{d}\pm 1.76$
3	WB2	$6^{bcd}\pm 0.66$	$6^{bcd}\pm 0.69$	$7^{a}\pm 0.91$	$5^{ef}\pm 1.15$	$5^{ef}\pm 1.12$	$4^{efg}\pm 1.21$	$6^{cde}\pm 1.09$	$6^{c}\pm 0.50$
4	WB3	$7^{bc}\pm 0.91$	$7^{bc}\pm 0.99$	$6^{ab}\pm 1.01$	$6^{de}\pm 1.16$	$4^{f}\pm 1.29$	$4^{gh}\pm 1.27$	$6^{bcd}\pm 1.04$	$6^{bc}\pm 0.62$
5	WB4	$6^{bcd}\pm 0.79$	$6^{cd}\pm 0.82$	$6^{ab}\pm 0.97$	$6^{cd}\pm 1.13$	$5^{def}\pm 1.04$	$5^{def}\pm 1.10$	$5^{fg}\pm 1.44$	$6^{c}\pm 0.94$
6	WB5	$6^{cd}\pm 1.00$	$6^{bcd}\pm 0.89$	$6^{ab}\pm 0.61$	$4^{f}\pm 1.61$	$6^{cde}\pm 1.62$	$5^{d}\pm 1.54$	$5^{efg}\pm 1.01$	$6^{bc}\pm 0.80$
7	WS1	$7^{b}\pm 1.01$	$7^{b}\pm 0.83$	$6^{a}\pm 0.71$	$6^{bc}\pm 0.65$	$7^{b}\pm 0.85$	$6^{b}\pm 0.91$	$7^{b}\pm 0.82$	$7^{b}\pm 0.79$
8	WS2	$6^{cd}\pm 0.65$	$6^{bcd}\pm 0.76$	$7^{a}\pm 1.23$	$6^{bc}\pm 0.94$	$6^{bc}\pm 0.72$	$6^{bc}\pm 0.89$	$6^{bc}\pm 0.89$	$6^{bc}\pm 0.71$
9	WS3	$7^{bc}\pm 1.08$	$7^{bc}\pm 0.98$	$6^{b}\pm 1.08$	$6^{de}\pm 1.16$	$6^{cd}\pm 1.42$	$5^{cd}\pm 1.29$	$6^{bcd}\pm 1.12$	$6^{bc}\pm 1.39$
10	WS4	$6^{bcd}\pm 0.92$	$6^{cd}\pm 1.29$	$7^{a}\pm 0.94$	$6^{bc}\pm 1.22$	$3^{g}\pm 1.19$	$3^{i}\pm 1.08$	$6^{cde}\pm 1.68$	$6^{c}\pm 0.85$
11	WS5	$6^{cd}\pm 1.17$	$6^{bcd}\pm 0.90$	$6^{ab}\pm 0.61$	$5^{ef}\pm 1.47$	$4^{f}\pm 1.66$	$4^{fg}\pm 1.59$	$5^{def}\pm 1.54$	$6^{bc}\pm 0.67$

Values are Means±standard deviations of three (3) replicate. Data in the same column bearing different superscript are significantly different ($p<0.05$)

Key: WY: whole water yam flour (100%); WB1: (90:10): water yam + boiled black turtle bean flour; WB2: (80:20): water yam + boiled black turtle bean flour; WB3: (70:30): Water yam + boiled black turtle bean flour; WB4: (60:40) Water Yam + Boiled Black Turtle Bean Flour; WB5: (50:50) Water Yam + Boiled Black Turtle Bean Flour; WS1: (90:10): Water Yam + Soaked Black Turtle Bean Flour; WS2: (80:20): Water Yam + Soaked Black Turtle Bean Flour; WS3: (70:30) Water Yam + Soaked Black Turtle Bean Flour; WS4: (60:40) Water Yam + Soaked Black Turtle Bean Flour; WS5: (50:50) water yam + soaked black turtle flour

CONCLUSION

This study revealed the usefulness of water yam and black turtle bean both of which are underexploited agricultural products in Nigeria. In addition, samples containing 10, 30, and 40% black turtle bean flour were the most desirable in terms of protein, thus improving the reconstitution ability compared with yam flour. Soaking decreased favourably the saponin and oxalate contents while boiling reduced significantly the phytate and tannin content of the flour samples. Stiff dough made from soaked sample WS1 (90:10) were mostly preferred by the panelist's asides the control (100 % water yam). Using water yam flour in the preparation of stiff dough could be improved in terms of the nutritional, and sensory properties of the stiff dough by adding an appropriate proportion as seen in samples WB5(50:50- water yam:boiled black Turtle Bean), and WB4(60:40-water yam:boiled black Turtle Bean), which contains high levels of protein (16.05 % and 15.94 %) makes them highly recommended. By replacing yam flour with water yam black turtle bean flour, yam's economic significance and its reliance on the production of stiff dough is decreased.

REFERENCES

Alozie, Y. E. and Ekerette, N. N. (2017). Proximate Compositions, Physicochemical and Sensory Properties of Gari Fortified with Soybean, Melon Seed and Moringa Seed Flours. *International Journal of Nutritional and Food Science*, 6 (2): 105– 110

AOAC (2010). Official Methods of Analysis International. 18th Edition. Association of Official Analytical Chemists. USA.

Babajide, J. M., Oyewole, O. B., and Obadina, O. A. (2006). An Assessment of the Microbial Safety of Dry Yam Processed in southwest nigeria. *African journal of biotechnology*.

Bhandari, m. R., kasai, t. And kawabata, j. (2013). Nutritional Evaluation of Wild Yam (*Dioscorea sp*.) Tubers of Nepal. *Food Chemistry,* 82(4): 619–623.

Chang, H. C., and Wu, L. C. (2008). Texture and Quality Properties of Chinese Fresh Egg Noodles Formulated with Green Seaweed (*Monostroma nitidum*) Powder. *Journal of Food Science, 73*: S398–S404.

Dauda, A. O., Abiodun, O. A., Arise, A. K. and Oyeyinka, S. A. (2018). Nutritional and Consumers Acceptance of Biscuit made from Wheat Flour Fortified with Partially Defatted Groundnut Paste. LWT Food Sci Technology, 90:265–9.

Dauda, A. O., Amida, O. H., Babayeju, A. A., Salami, K.O. and Oyelade, R. O. (2022). Quality Attributes of Stiff Dough Made from Blends of White, Water and Cocoyam Flour. *Nutrition* 17.8 04-18.

Haugh, W. and Lantzsch, H. J. (1993) Sensitive Method for Determination of Phytate in Cereals and Cereals Product, *Plant Foods for Human Nutrition*, 44:261–266

Iwe, M. O., Okereke, G. O. and A. N. Agiriga, A. N. (2014). Production and Evaluation of Bread Made from Modified Cassava Starch and Wheat Flour Blends, Agrotechnology 4(1): 133-139, https://doi.org/10.4172/2168-9881.1000133

Kalu, C. E., Alaka, I. C. and Ekwu, F. C. (2019). Anti-Nutritional and Amino Acid of Flour blends from Water Yam, Yellow Maize and African Yam Bean. Journal of Nutritiona and Food Sciences. Vol 1(5), 84-90.

Karim, O., Kayode, R. M., Adeoye, O. S. and Oyeyinka, A. T. (2013). Proximate, Mineral and Sensory Qualities of Amala Prepared from Yam Fortified with Moringa Leaf Powder. *Food Science and Quality Management*, 12, 10-22.

Liang, J., Han, B. Z., Nout, M. R. and Hamer, R. J. (2008). Effects of Soaking, Germination and Fermentation on Phytic Acid, Total and In Vitro Soluble Zinc in Brown rice. *Food Chemistry*, 110(4): 821–828.

Nwosu, J. N. (2010). Effect of Soaking, Blanching and Cooking on the Anti-nutritional Properties of Asparagus Bean (*Vigna sesquipedis*) Flour. *Journal of Nature and Science*, 8(8):163-167.

Odo, E. K. (2010). Properties of Trona and its Effect on the Cooking Time of Cowpeas. *Journal of Food Science and Agriculture* 29(16): 950 – 952.

Odoh, E. N., Okafor, R. O., Ikegwu, T. M., Okolo, C. A., Mba, J. C., Ezegbe, C. C., Olubusayo, K. O., Orjiakor, S. N., and Obiegbuna, J. E. (2022). Physicochemical and Sensory Properties of Unfermented Fufu Composite Flour Made from Cassava Sievate, Guinea Corn and Unripe Plantain Flours Blend. *American Journal of Food Science and Technology*, *10*(1): 27-34.

Okafor, D. C., Enweleuzoh, R. O., Ibeabuchi, J. C., Uzoukwu, A. E., Alagbaoso, S. O. and Udenkwo, C. (2015). Production of Flour Types from Black Bean (*Phaseolus vulgaris*) and Effect of pH and Temperature on Functional and Physio-chemical Properties of the Flours. *European Journal of Food Science and Technology* 3(2): 64-84.

Olapade, A. A. and Akinyanju, F. T. (2014). Chemical and Functional Properties and Performance of Blends of Water Yam (Dioscorea Alata) and Soybean (Glycine Max) Flours for Water Yam Ball (Ojojo) Preparation, *American Journal of Chemistry*, 4(3):89-96. doi: 10.5923/j.chemistry.20140403.01

Olaposi, R. A., Oladipupo, Q. A., Olumide, S. F. and Gbeminiyi, O. (2017). Effect of Soaking and Boiling on Anti-nutritional Factors, Oligosaccharide contents and Protein Digestibility of Newly developed Bambara Groundnut Cultivars. *Turkish Journal of Agriculture* 5(9): 1006-1014.

Onwuka, G. I. and Ihuma, C. (2007). Physicochemical Composition and Product Behavior of Flour and Chips from Two Yam spp. (*Dioscorea rotundata* and *Dioscorea alata*), *Resource. Journal of Applied Sci*ence, 2:35–38.

Siddiq, M., and Uebersax, M. A. (2013). Market Classes and Physical and Physiological Characteristics of Dry Beans. Dry Beans and Pulses*: Production, Processing and Nutrition.* John Wiley and Sons. Oxford, UK 55-74