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Evaluation of breads made from wheat flour, modified white yam/trifoliate yam/sweet potato starches and *Moringa Oleifera* seed flour blends

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Abstract

Starches obtained from selected roots and tubers (white yam, trifoliate yam and sweet potato) were physically and chemically modified through heat moisture treatment and acetylation respectively while highly nutritious flour was processed from *Moringa oleifera* seeds. Composite flours of 85% wheat flour, 10% native/modified starch and 5% *Moringa oleifera* seed flour blends were developed for production of composite breads. Nutritional compositions and baking properties of these composite breads were investigated against those of control samples (i.e. 100% wheat flour bread). Nutritionally, composite breads were significantly ($p<0.05$) superior to control breads while in terms of baking properties, the control breads did not significantly ($p<0.05$) differ from composite breads. Composite bread sample NSPB (i.e. made from composite flour of 85% wheat flour: 10% native sweet potato starch: 5% *Moringa oleifera* seed flour) had highest values in crude fibre (1.35%), protein (11.75%), calcium (116.49 mg/100g), iron (2.81 mg/100g), magnesium (57.23 mg/100g), vitamin A (3.980 µg/g), vitamin B_1 (0.067 mg/100g), vitamin B_2 (0.096 mg/100g), vitamin B_3 (0.400 mg/100g), vitamin B_6 (0.440 mg/100g) and vitamin C (13.560 mg/100g); but had lowest values in carbohydrate (45.90%). NTYB (i.e. bread made from composite flour of 85% wheat flour: 10% native trifoliate yam starch: 5% *Moringa oleifera* seed flour) led in ash content (2.40%), crude fat content (1.80%) and phosphorus content (66.91 mg/100g); but toddled in height (5.23 cm). Sample PTYB (i.e. bread made from composite flour of 85% wheat flour: 10% heat moisture treated trifoliate yam starch: 5% *Moringa oleifera* seed flour) recorded highest values in crude fibre content (1.35%), specific volume (2.20 cm^3/g) and lowest in crude fat content (1.30%); while control bread sample CTLB (i.e. made from 100% wheat flour) got highest values in moisture content (38.40%), magnesium (58.15 mg/100g) and insignificantly ($p<0.05$) scored highest in general acceptability (6.75) but lagged behind in crude fat content (1.05%), crude fibre content (0.75%), protein content (10.80%), energy value (240.05 Kcal), calcium content (112.40 mg/100g), iron content (1.81 mg/100g), phosphorus content (63.88 mg/100g), vitamin A (1.84 µg/g), vitamin B_1 (0.036 mg/100g), vitamin B_2 (0.065 mg/100g), vitamin B_3 (0.170 mg/100g), vitamin B_6 (0.210 mg/100g), vitamin C (11.380 mg/100g) and shelf-stability potential (i.e. highest moisture content of 38.40%). Sample CWYB (i.e. bread made from composite flour of 85% wheat flour: 10% acetylated white yam starch: 5% *Moringa oleifera* seed flour) recorded best values in carbohydrate content (53.15%), energy content (270.05 Kcal) and shelf-stability potential (i.e. lowest moisture content of 31.00%) but lowest values in ash content (2.00%), magnesium content (55.23%) and general acceptability (5.75). Sample PWYB (i.e. bread made from composite flour of 85% wheat flour: 10% heat moisture treated white yam starch: 5% *Moringa oleifera* seed flour) also obtained highest value of 1.35% in crude fibre content.

Keywords: modified white yam/trifoliate yam/sweet potato starches; wheat flour, *moringa oleifera* seeds, bread

Introduction

Bread is a fermented confectionary product produced mainly from wheat flour, water, yeast and salt by a series of operations including mixing, kneading, proofing, shaping and baking (Dewettinck *et al.*, 2008; Makinde and Akinoso, 2014) [6, 22]. The consumption of bread and other baked foods such as biscuits, doughnuts and cakes produced from wheat flour is very popular in Nigeria, but the poor nutritional content of wheat flour and high cost of importation of wheat flour are of major concerns (Nwosu *et al.*, 2014) [24]. The search to close-up these gaps and others not mentioned here, has led food scientists to employ composite flour technology in breadmaking, but poor baking properties of these composite breads pose a big threat to advancement of this advantageous technology.

In developing countries like Nigeria where the supply of some vital nutrients in our diet is inadequate to meet the exponential growth in population, supplementing wheat flour with high nutritious materials like *Moringa oleifera* seed flour will greatly improve the nutritional quality of such flour-based baked product. Of course, this is one of the ways of addressing malnutrition in developing countries. Composite flour is a mixture of flours/starches and other ingredients meant to replace wheat flour totally or partially in pastry or baked products (Shittu *et al.*, 2007; Igbabul *et al.*, 2018) [35, 11]. Composite flour technology has many advantages among which are: it plays a vital role in complementing the deficiency of essential nutrients, saves hard currency; increases utilizations of local crops, promotes control of postharvest food losses, promotes high yielding local plant species and enhances overall use of domestic agriculture (Shittu *et al.*, 2007; Iwe *et al.*, 2014; Igbabul *et al.*, 2014; Igbabul *et al.*, 2018) [35, 15, 12, 11]. However, the use of composite flours for commercial production of bread is not common in Nigeria due to shortcomings on their baking properties.

According to Shittu *et al.* (2007) [35]. If bread is to be produced without wheat flour, one has to compensate for the poor gas retention capacity of a gluten-free flour batter. Loaf volume, weight, specific volume, tristimulus colour parameters, fresh crumb moisture, density, porosity and softness as well as dried crumb hardness of composite flour bread varies significantly with wheat flour bread (Shittu *et al.*, 2007; Iwe *et al.*, 2014) [35, 15]. A better gas retention maintained throughout the baking process eventually results in larger loaf volumes. For instance, baking with cassava starch instead of flour showed that bread making potential of cassava flour is determined both by the starch and non-starch fraction (Iwe *et al*., 2014) [15].

Starch is an important component of bakery products, functionally and nutritionally since it constitutes about 65-85% of grain based flour (Peter *et al*., 2013) [30]. Also formulations of composite flours with starches show better baking responses than those with flours (Khali *et al*., 1999; Iwe *et al.,* 2014) [18, 15]. Studies have revealed that processing of starch from cereals is far more expensive than other sources like roots and tubers (Perez-Carillo and Serner-Saldiva, 2006; Okereke, 2012; Iwe *et al*., 2014) [26, 15]. Roots and tubers (i.e obtained from plants that store edible starch materials in subterranean stems, roots, rhizomes, corms and tubers) are second in importance to cereals as global sources of carbohydrates (Ugwu, 2006) [38]. The growing importance of roots and tubers come from their potentials to replace cereals, as sources of new starches and basis for processed products. Examples of roots and tubers are potatoes, sweet potatoes, beets, arrowroots, carrots, taro, cassava, cocoyam and yams (FAO, 1994; Iwe *et al*., 2014; Saranraj *et al*., 2019) [8, 15, 32]. Presently Nigeria is the leading world yam producer (Iwuchukwu and Okwor, 2017) [16]. And the second leading producer of sweet potato globally (Udemezue, 2019) but yet yams and sweet potatoes have not been fully utilized domestically and industrially. At least expanded utilizations of yams and sweet potatoes through industrial exploitations will curb postharvest food losses threatening food security, create job opportunities and accelerate economic growth.

Starches from different origins have different compositional and structural properties and it is known that such variance in starches can affect the properties of bread dough (Vatanasuchart, *et al.*, 2005) [39]. Besides, the native or unmodified starches exhibit limited applications (Ihekoronye and Ngoddy, 1985; Kavlani *et al*., 2012) [13, 17]. due to their inherent weakness of hydration, low shear stress resistance, thermo-decomposition, high retrogradation and syneresis, poor swelling and structural organization, poor processability and solubility in common organic solvents. To enhance viscosity, texture and stability among many food and non-food industrial applications, starches and their derivatives are modified by physically, chemically, enzymatically and genetically means (Kavlani *et al*., 2012) [17]. Interestingly, studies have proved that acceptable bread could be produced with up to the 15% level of incorporation of starch or flour (Ciaceo and D'Appolonia, 1978; Okereke, 2012; Igbabul *et al.*, 2014; Nwosu *et al.*, 2014; Iwe et al., 2014) [5, 26, 12, 24, 15]. Thus, native and modified starches obtained from selected roots and tubers- white yam (*Dioscorea rotundata*), trifoliate yam (*Dioscorea dumetorum)* and sweet potato (*Ipomoea batatas*), will be blended with wheat-*Moringa oleifera* seed composite flours for the production of breads in order to investigate their nutritional, physical and sensory properties.

Materials and Methods

Materials

Fresh tubers of white yam (*Dioscorea rotundata*), trifoliate yam (*Dioscorea dumetorum*) and roots of sweet potato (*Ipomoea batatas*) were obtained from Benue State Agricultural Development Authority (BNARDA), Makurdi, Benue State, Nigeria. Wheat flour and baking ingredients (sugar, salt, yeast and butter) were obtained from Wurukum market while matured *Moringa oleifera* seeds were obtained from University of Agriculture farms, Makurdi, Benue State. Water used was obtained from the Department of Chemistry laboratory, Benue State University, Makurdi, Benue State.

Methods

Starch extraction: Starch was extracted from cleaned, peeled and macerated tubers using the method of Onabolu *et al.* (2003) [28].

Modification of the Starches: Portions of oven dried starch from the white yam starch/trifoliate yam starch/sweet potato starch were physically and chemically modified through heat moisture treatment (HMT) and acetylation processes respectively. For heat moisture treatment, the method of Lim *et al*. (2001) [20]. was used. The method of Sathe and Salunkhe (1981) was adopted for acetylation.

Production of *Moringa oleifera* Seed Flour: Flour from cleaned matured *Moringa oleifera* seeds was produced using the method of Bolarinwa *et al.* (2017).

Formulation of the Flour Blends for the Composite Flour: The wheat flour, white yam/trifoliate yam/sweet potato starch and *Moringa oleifera* seed flour were mixed in Philip blender (HR2811 model) at full speed for 5 minutes to obtain ten different flour blends labeled samples CTLF, NWYF, NTYF, NSPF, PWYF, PTYF, PSPF, CWYF, CTYF and CSPF as shown in Table 1.

Production of Bread Samples Using Straight Dough Method

Ten different bread samples were produced and coded as CTLB, NWYB, NTYB, NSPB, PWYB, PTYB, PSPB, CWYB, CTYB and CSPB. Sample CTLB served as control and contained 100% wheat flour. Samples NWYB, NTYB, NSPB, PWYB, PTYB, PSPB, CWYB, CTYB and CSPB. Sample CTLB contained composite flour of 85% wheat flour, 10% starch and 5% *Moringa oleifera* seed flour (Iwe *et al.,* 2014; Bolarinwa *et al.,* 2017) [15]. for each starch sample; and other ingredients for bread production as presented in Table 2. The straight dough method was used to produce the bread samples. All the ingredients (flour, salt, water, sugar, yeast and sugar) were added together at mixing stage and kneaded to obtain the dough (Igbabul, *et al.*, 2014) [12]. The different dough samples were placed in baking pans smeared with vegetable oil and covered for the dough to ferment resulting in gas production and gluten development for about 1 hour. The dough samples were then baked in the oven at 230^{0}C for 30 minutes. The baked loaves were carefully removed from the pans and allowed to cool and packaged in polyethylene bags for analyses. The procedure is shown in Figure 1.

Table 1: Formulation of flour blends of wheat flour, starch and *Moringa oleifera* seeds flour

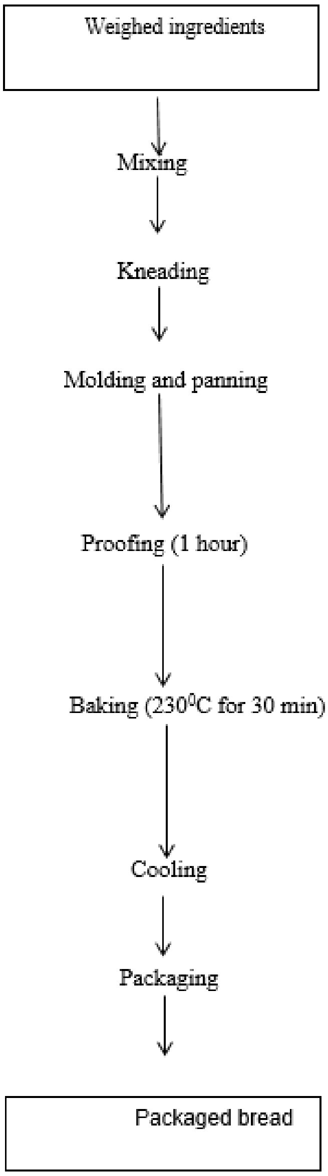
Ingredients			
Flour Blends	**Wheat Flour (g)**	**Starch (g) (White yam/trifoliate yam/sweet potato)**	***Moringa oleifera* Seed Flour (g)**
CTLF (Control)	100.0	0.0	0.0
NWYF	85.0	10.0	5.0
NTYF	85.0	10.0	5.0
NSPF	85.0	10.0	5.0
PWYF	85.0	10.0	5.0
PTYF	85.0	10.0	5.0
PSPF	85.0	10.0	5.0
CWYF	85.0	10.0	5.0
CTYF	85.0	10.0	5.0
CSPF	85.0	10.0	5.0

Source: Modified Iwe *et al.* (2014) [15] and Bolarinwa *et al.* (2017)
CTLF = 100% wheat flour (control)
NWYF= Flour blend (85% wheat flour:10% native White yam starch: 5% *Moringa oleifera* seed flour)
NTYF = Flour blend (85% wheat flour: 10% native Trifoliate yam native starch: 5% *Moringa oleifera* seed flour:)
NSPF = Flour blend (85% wheat flour: 10% native sweet potatoe starch 5% *Moringa oleifera* seed flour:)
PWYF= Flour blend (85% wheat flour: 10% physically modified (HMT) White yam starch: 5% *Moringa oleifera* seed flour:)
PTYF = Flour blend (85% wheat flour:10% physically modified (HMT) Trifoliate yam starch: 5% *Moringa oleifera* seed flour)
PSPF = Flour blend (85% wheat flour: 10% physically modified (HMT) sweet potato starch: 5% *Moringa oleifera* seed flour)
CWYF = Flour blend (85% wheat flour:10% chemically modified (acetylated) White yam starch:5% *Moringa oleifera* seed flour)
CTYF = Flour blend (85% wheat flour: 10% chemically modified (acetylated) Trifoliate yam starch: 5% *Moringa oleifera* seed flour)
CSPF = Flour blend (85% wheat flour: 10% chemically (acetylated) sweet potato starch: 5% *Moringa oleifera* seed flour:)

Table 2: Recipe formulations for production of the bread samples

Ingredients								
Bread Samples	**Wheat Flour (g)**	**Starch (g)**	***Moringa oleifera* Seed Flour**	**Salt (g)**	**Yeast (g)**	**Butter (g)**	**Sugar (g)**	**Water (ml)**
CTLB	100.0	0.0	0.0	2.5	2.5	2.0	2.0	65
NWYB,	85.0	10.0	5.0	2.5	2.5	2.0	2.0	65
NTYB	85.0	10.0	5.0	2.5	2.5	2.0	2.0	65
NSPB	85.0	10.0	5.0	2.5	2.5	2.0	2.0	65
PWYB	85.0	10.0	5.0	2.5	2.5	2.0	2.0	65
PTYB	85.0	10.0	5.0	2.5	2.5	2.0	2.0	65
PSPB	85.0	10.0	5.0	2.5	2.5	2.0	2.0	65
CWYB	85.0	10.0	5.0	2.5	2.5	2.0	2.0	65
CTYB	85.0	10.0	5.0	2.5	2.5	2.0	2.0	65
CSPB	85.0	10.0	5.0	2.5	2.5	2.0	2.0	65

Source: Modified Igbabul *et al.* (2014) [12] and Bolarinwa *et al.* (2017)
CLTB = Bread of 100% wheat flour (control)
NWYB = Bread of composite flour (85% wheat flour: 10% native White yam starch:5% *Moringa oleifera* seed flour)
NTYB = Bread of composite flour (85% wheat flour: 10% nativetrifoliate yam starch:5% *Moringa oleifera* seed flour)
NSPB = Bread of composite flour (85% wheat flour: 10% native sweet potatoestarch:5% *Moringa oleifera* seed flour)
PWYB = Bread of composite flour (85% wheat flour: 10% HMT White yam starch:5% *Moringa oleifera* seed flour)
PTYB = Bread of composite flour ((85% wheat flour: 10% HMT trifoliate yam starch:5% *Moringa oleifera* seed flour)
PSPB = Bread of composite flour (85% wheat flour: 10% HMT sweet potato starch: 5% *Moringa oleifera* seed flour)
CWYB = Bread of composite flour (85% wheat flour: 10% acetylated White yam starch: 5%*Moringa oleifera* seed flour)
CTYB = Bread of composite flour (85% wheat flour: 10% acetylated Trifoliate yam starch: 5% *Moringa oleifera* seed flour)
CSPB= Bread of composite flour (85% wheat flour: 10% acetylated sweet potatoe starch: 5% *Moringa oleifera* seed flour)



Source: Modified Igbabul *et al.* (2014) [12] ; Bolarinwa *et al.* (2017)

Fig 1: Flow chart for production of bread

Determination of the proximate composition of bread and cookies samples

Proximate analyses were carried out on the bread samples to determine the moisture, ash, crude fibre, fat, protein and carbohydrate contents using the method outlined by the Association of Official Analytical Chemists (AOAC, 2005) [2].

Determination of Energy Content/Value: The energy values of the bread samples were calculated in Kcal/100g, using the Atwater Factor Method, as described by Igbabul *et al.* (2018) [11].

$$E.V = (4CP + 9CF + 4C)$$

Where E.V = Energy value or Energy content measured in kilocalories (Kcal)

CP = Crude protein content
CF = Crude Fat content
C = Carbohydrate content.

Determination of minerals (iron, magnesium, calcium and phosphorous) contents of the bread samples: Calcium, iron, magnesium and phosphorus contents of the bread sample was determined using the method described by AOAC (2005) [2].

Determination of vitamins (A, B_1, B_2, B_3, B_6 and C) contents of bread samples

Vitamin A content: Vitamin A content of the bread samples was determined using the procedure described by Singh *et al.* (2015) [36].

Vitamin B_1 (thiamine) content: Vitamin B_1 (thiamine) content of the bread samples was determined using the method described by Okwu and Ndu (2006) [27].

Vitamin B_2 (Riboflavin) content: The method described by Okwu and Ndu (2006) [27]. was adopted for determination of vitamin B_2 (riboflavin) contents of the bread samples.

Vitamin B_3 (niacin) contents of bread samples were determined by the method described by Okwu and Ndu (2006) [27].

Vitamin B_6 (Pyridoxine) content: The method of Kos and Surmann (2006) [19]. was used in determination of vitamin

B_6 (pyridoxine) contents of the bread samples.

Vitamin C (Ascorbic acid) content**:** Vitamin C (ascorbic acid) contents of the bread samples were determined using the method for vitamin assay (inter-science publishers, 2006) as described by Agomuo *et al*. (2015) [1].

Determination of the physical properties of bread samples

Height of the Bread Samples: Loaf height was measured using a meter rule (Sengev *et al.*, 2013) [34].

The Specific Volume of Bread Samples: The Loaf volume was measured by seed displacement method of Giami *et al.* (2004) [9]. Loaf mass was determined by simply measuring with an electronic balance while Specific volume was obtained by dividing the loaf volume of bread by its corresponding loaf mass. Thus, Specific volume = V/ W (cm^3/g).

$$S.V = \left(\frac{V}{W}\right)$$

Where:

S.V = Specific Volume of bread sample in cm^3/g

V = Volume of the bread sample in cm^3

W = Mass of the bread sample in g

Sensory analyses of the bread samples

Samples of bread produced were subjected to sensory analysis on a nine point hedonic scale (Ihekoronye and Ngoddy, 1985) [13]. For consumer acceptance and preference. The quality attributes tested for bread were

appearance, aroma, mouth-feel, taste and general acceptability.

Experimental design

The experiments were fit into a one way Analysis of variance (ANOVA). Nine (9) treatments were generated in triplicates for each experiment on the proximate compositions, chemical and functional properties of the native and modified starches, yielding a total of twenty-seven (27) samples/experiment analyzed. Then, for analyses of proximate compositions, micronutrient compositions, physical and sensory properties of bread and cookies, ten (10) treatments were generated in triplicates for each experiment yielding a total of thirty (30) samples per experiment to be analyzed.

Statistical analysis

Results of all determinations were expressed as means of triplicate values. Data were subjected to one-way Analysis of Variance (ANOVA), and the means were separated using Duncan's multiple range test to determine the significant differences at 5% probability ($p<0.05$). An IBM SPSS Statistical package (version 20.0) was used for all statistical analyses.

Results and discussion

Table 3. Proximate compositions (%) of bread samples made from the different flour blends

Bread Sample	Moisture	Ash	Crude fat	Crude fibre	Protein	Carbohydrate	Energy value (Kcal)
CTLB	38.40 ± 0.00^{a}	2.15 ± 0.07^{c}	1.05 ± 0.07^{e}	0.75 ± 0.07	10.80 ± 0.00^{g}	46.85 ± 0.07^{f}	240.05 ± 0.35^{g}
NWYB	31.60 ± 0.28^{h}	2.20 ± 0.00^{bc}	1.60 ± 0.07^{b}	1.33 ± 0.04	11.30 ± 0.07^{de}	51.98 ± 0.46^{b}	267.50 ± 0.92^{b}
NTYB	35.00 ± 0.00^{e}	2.40 ± 0.00^{a}	1.80 ± 0.00^{a}	1.33 ± 0.11	11.50 ± 0.07^{bc}	47.98 ± 0.04^{e}	254.10 ± 0.42^{d}
NSPB	37.20 ± 0.14^{c}	2.30 ± 0.14^{ab}	1.50 ± 0.14^{bc}	1.35 ± 0.07	11.75 ± 0.07^{a}	45.90 ± 0.14^{g}	244.10 ± 0.16^{f}
PWYB	32.60 ± 0.14^{g}	2.10 ± 0.00^{cd}	1.35 ± 0.07^{cd}	1.35 ± 0.07	11.15 ± 0.14^{ef}	51.45 ± 0.28^{c}	262.55 ± 1.20^{c}
PTYB	31.40 ± 0.00^{h}	2.20 ± 0.07^{bc}	1.30 ± 0.07^{d}	1.35 ± 0.14	11.40 ± 0.00^{cd}	52.45 ± 0.00^{b}	267.10 ± 0.64^{b}
PSPB	36.40 ± 0.14^{d}	2.18 ± 0.04^{bc}	1.40 ± 0.00^{cd}	1.30 ± 0.14	11.65 ± 0.07^{ab}	47.08 ± 0.11^{f}	247.50 ± 0.14^{e}
CWYB	31.00 ± 0.00^{i}	2.00 ± 0.00^{d}	1.45 ± 0.07^{bcd}	1.30 ± 0.00	11.10 ± 0.07^{f}	53.15 ± 0.14^{a}	270.05 ± 0.35^{a}
CTYB	37.60 ± 0.14^{b}	2.10 ± 0.07^{cd}	1.60 ± 0.00^{b}	1.30 ± 0.07	11.30 ± 0.14^{de}	46.10 ± 0.28^{g}	244.00 ± 0.57^{f}
CSPB	34.60 ± 0.00^{f}	2.08 ± 0.04^{cd}	1.40 ± 0.00^{cd}	1.30 ± 0.14	11.50 ± 0.00^{bc}	49.13 ± 0.18^{d}	255.10 ± 0.71^{d}

Values are mean± standard deviation of triplicate determinations

Values with different superscripts within the same column are significantly different at ($P<0.05$).

KEY: CTLB = Bread of 100%Wheat flour (Control)

NWYB= Bread of composite flour (85% wheat flour: 10% native white yam starch: 5% Moringa oleifera seed flour)

NTYB = Bread of composite flour (85% wheat flour: 10% native trifoliate yam starch: 5% Moringa oleifera seed flour)

NSPB = Bread of composite flour (85% wheat flour: 10% native sweet potato starch: 5% Moringa oleifera seed flour)

PWYB = Bread of composite flour (85% wheat flour: 10% physically modified white yam starch: 5% Moringa oleifera seed flour)

PTYB = Bread of composite flour (85% wheat flour: 10% physically modified trifoliate yam starch: 5% Moringa oleifera seed flour)

PSPB = Bread of composite flour (85% wheat flour: 10% physically modified sweet potato starch: 5% Moringa oleifera seed flour)

CWYB = Bread of composite flour (85% wheat flour: 10% chemically modified white yam starch: 5% Moringa oleifera seed flour)

CTYB = Bread of composite flour (85% wheat flour: 10% chemically modified white yam starch: 5% Moringa oleifera seed flour)

CSPB = Bread of composite flour (85% wheat flour: 10% chemically modified white yam starch: 5% Moringa oleifera seed flour)

Proximate Compositions of the Breads

Results of the proximate compositions of the composite bread samples made from wheat flour, native/modified starch and *Moringa oleifera* seed flour blends are presented in Table 3. The moisture content varied significantly ($p<0.05$) between 38.40 – 31.00%. Bread sample CWYB had the lowest value of 31.00% while bread sample CTLB had the highest value of 38.40%. The results indicate that bread sample CWYB will be more shelf-stable than the other bread samples and thus could be traced to be as a result of type of starch (i.e acetylated white yam starch) and *Moringa oleifera* seed flour incorporated in the flour blend. Furthermore, modification method and starch source significantly ($p<0.05$) affected the hydrophilic tendencies of bread samples produced (Haq *et al*., 2019). The results further revealed that all composite bread samples had significantly ($p<0.05$) more storage stabilities than bread sample CTLB (i.e 100% wheat flour bread). This result is in agreement with the reports of Sengev *et al*. (2013) [34]. The moisture content of food can serve as an index of food quality. Measurements of the moisture contents of bread samples are important because of its potential impact on the sensory, physical, and microbial properties of the bread (Sengev *et al*. 2013) [34].

The ash contents of the bread samples significantly ($p<0.05$) ranged from 2.00 – 2.40% with sample CWYB having the lowest value while sample NTYB had the highest value. Ash content reflects the mineral content of the bread sample. This indicates that *Moringa oleifera* seed flour gave the highest improvement on the mineral content to the bread sample NTYB. Furthermore the modification of the starches decreased the ash contents of the bread samples of trifoliate yam starches significantly ($p<0.05$) but insignificantly ($p<0.05$) for bread samples of white yam and sweet potato starches with the use of physical modification (HMT) and significantly ($p<0.05$) with the use of chemical modification (acetylation). Chemical modification (acetylation) decreased the ash contents of the bread samples more than that done by physical modification for all the three selected starch sources.

The crude fat contents of the bread samples varied significantly ($p<0.05$) between 1.05% (sample CTLB) to 1.80% (sample NTYB). All the composite bread samples had significantly ($p<0.05$) higher fat contents more than the wheat bread (sample CTLB- 100% wheat flour bread) due to incorporation of *Moringa oleifera* seed flour in their flour blends. *Moringa oleifera* seeds are sources of oils of high levels of unsaturated fatty acids (oleic fatty acids) that are good for human consumption (Madubuike *et al*., 2015) [21]. The results reveal that botanical sources of starches and modification methods significantly ($p<0.05$) affected fat contents of the bread obtained through supplementation with *Moringa oleifera* seed flour. Closer observations show that modified starches incorporated in the flour blends resulted in decreased fat contents of the bread samples when compared with those of the native starches irrespective of their botanical sources. Fats play an important role as 'lubricants' in bread (Ihekoronye and Ngoddy, 1985) [13]. and oils from *Moringa oleifer*a seeds are of premium quality, comparable to olive oil (Warra, 2014) [40].

The crude fibre content insignificantly ($p<0.05$) ranged from 0.75 – 1.35%, with bread samples NSPB, PWYB and PTYB taking the lead values of 1.35%; followed very closely to them with values of 1.33% were samples NWYB and NTYB while bread sample CTLB (100% wheat flour bread) toddled the least with 0.75%. The indication is that supplementation of the bread with *Moringa oleifera* seed flour improved their dietary crude fibre contents. Studies have shown that adequate dietary crude fibre in a diet enhances gastro intestinal and cardiovascular health, glycaemic control and improved morbidity of diabetic patients (Igbabul *et al*., 2018; Inyang *et al*., 2018) [11, 14]. From the results, physical modification of starches through heat moisture treatment led to slight increase in crude fibre contents of breads of white yam and trifoliate yam starch sources, but led to decrease for that of sweet potato starch sources while chemical modification of starches through acetylation led to decrease in crude fibre contents of breads in comparison with those of their native starches.

The protein contents of the bread samples significantly ($p<0.05$) ranged from 10.80% (bread sample CTLB) to 11.75% (bread sample NSPB). All composite bread samples improved significantly ($p<0.05$) on protein contents when compared with the bread sample CTLB (100% wheat flour bread that served as control) due to the incorporation of high protein *Moringa oleifera* seed flour (Chinma *et al*., 2014; Gopalakrishnan *et al*., 2016; Bolarinwa *et al*., 2017; Igbabul *et al*., 2018) [10, 11]. These high protein breads are recommendable for people vulnerable to celiac disease since their gluten contents are relatively low. This result is in line with the reports of Sengev *et al*. (2013) [34] and Igbabul *et al*. (2018) [11]. on the substitution effects of *Moringa oleifera* leaf/seed flour on the protein contents of bakery products. From the result, inclusions of heat moisture treated (physically modified) starches of white yam, trifoliate yam and sweet potato to the bread formulations resulted in the insignificant ($p<0.05$) decrease of protein contents when compared with that of their corresponding native starches. This trend was also the same for bread samples of acetylated (chemically modified) starches. Thus modification of starches caused the decrease of protein contents of bread samples in comparison with that of their various native starches. Among the three starch sources (white yam, trifoliate yam and sweet potato), bread of sweet potato starches had highest values of 11.75%, 11.65% and 11.50% in native, physical (HMT) and chemical (acetylated) categories respectively. Bread samples of white yam starches followed similar trend with lowest values of 11.30%, 11.15% and 11.10% in native, physical (HMT) and chemical (acetylated) categories respectively.

The carbohydrate contents of the bread samples varied significantly ($p<0.05$) between 53.15 and 45.90%, with bread sample CWYB having the highest value (53.15%) and bread sample NSPB having the lowest value (45.90%). Breads of low carbohydrate content are good for people with low energy levels and also help to control weight gain and obesity. The high carbohydrate breads are good sources of energy with low glycemic index. The 100% wheat bread contains refined flour of high glycemic index that leads to weight gain, obesity, heart disease and a host of digestive disorders. From the result, the formulations of flour blends that produced bread samples such as CWYB (53.15%), PTYB (52.45%), NWYB (51.98%), PWYB (51.45%), CSPB (49.13%) and NTYB (47.98%) could be adopted by bread bakers since their carbohydrate contents were significantly ($p<0.05$) higher than that of CTLB (46.85%).

The energy contents of the bread samples significantly ($p<0.05$) ranged from 240.05 – 270.05 Kcal with the bread sample CWYB having the highest value (270.05 Kcal) while bread sample CTLB (100% wheat flour bread) had the lowest value of 240.05 Kcal. From the result, all composite bread samples are significantly ($p<0.05$) higher in energy contents than control sample (bread sample CTLB) due to the effect of incorporation of starches and *Moringa oleifera* seed flour. Among the three botanical sources of starch, white yam took the lead values in all the three categories of modifications.

Table 4: Mineral Contents (mg/100g) of composite bread samples made from wheat flour, native/modified starch and *Moringa oleifera* seed flour blends

Bread Sample	Calcium	Iron	Magnesium	Phosphorus
CTLB	112.40 ± 0.00^{i}	1.81 ± 0.01^{g}	58.15 ± 0.21^{a}	63.88 ± 0.25^{g}
NWYB	114.08 ± 0.00^{e}	2.50 ± 0.07^{cde}	56.32 ± 0.00^{d}	65.34 ± 0.34^{f}
NTYB	114.72 ± 0.24^{d}	2.63 ± 0.11^{bc}	56.75 ± 0.00^{c}	66.91 ± 0.16^{a}
NSPB	116.49 ± 0.11^{a}	2.81 ± 0.07^{a}	57.23 ± 0.10^{b}	66.36 ± 0.00^{cd}
PWYB	113.82 ± 0.10^{ef}	2.38 ± 0.00^{ef}	55.85 ± 0.07^{e}	65.10 ± 0.00^{fg}
PTYB	113.59 ± 0.13^{fg}	2.51 ± 0.07^{cde}	56.22 ± 0.28^{d}	66.73 ± 0.11^{ab}
PSPB	116.17 ± 0.14^{b}	2.70 ± 0.14^{ab}	56.90 ± 0.21^{bc}	66.07 ± 0.10^{de}
CWYB	113.40 ± 0.14^{gh}	2.24 ± 0.00^{f}	55.22 ± 0.00^{f}	64.85 ± 0.00^{g}
CTYB	113.30 ± 0.07^{h}	2.43 ± 0.04^{de}	55.79 ± 0.13^{e}	66.51 ± 0.00^{bc}
CSPB	115.89 ± 0.00^{c}	2.59 ± 0.00^{bcd}	56.41 ± 0.16^{d}	65.72 ± 0.17^{e}

Values are mean± standard deviation of triplicate determinations
Values with different superscripts within the same column are significantly different at ($P<0.05$).
KEY: CTLB = Bread of 100%Wheat flour (Control)
NWYB= Bread of composite flour (85% wheat flour: 10% native white yam starch: 5% Moringa oleifera seed flour)
NTYB = Bread of composite flour (85% wheat flour: 10% native trifoliate yam starch: 5% Moringa oleifera seed flour)
NSPB = Bread of composite flour (85% wheat flour: 10% native sweet potato starch: 5% Moringa oleifera seed flour)
PWYB = Bread of composite flour (85% wheat flour: 10% physically modified white yam starch: 5% Moringa oleifera seed flour)
PTYB = Bread of composite flour (85% wheat flour: 10% physically modified trifoliate yam starch: 5% Moringa oleifera seed flour)
PSPB = Bread of composite flour (85% wheat flour: 10% physically modified sweet potato starch: 5% Moringa oleifera seed flour)
CWYB = Bread of composite flour (85% wheat flour: 10% chemically modified white yam starch: 5% Moringa oleifera seed flour)
CTYB = Bread of composite flour (85% wheat flour: 10% chemically modified white yam starch: 5% Moringa oleifera seed flour)
CSPB = Bread of composite flour (85% wheat flour: 10% chemically modified white yam starch: 5% Moringa oleifera seed flour)

Mineral contents of the bread samples made from the flour blends.

Results of the mineral contents of composite bread samples made from wheat flour, native/modified starch and *Moringa oleifera* seed flour blends are presented in Table 4.

The results of the mineral contents of the composite bread samples made from wheat flour, native/modified starch and *Moringa oleifera* seed flour blends are presented in Table 8. The calcium contents of the bread samples significantly ($p<0.05$) ranged from 112.40 mg/100g (control sample CTLB) to 116.49 mg/100g (NSPB). All composite bread samples significantly ($p<0.05$) appreciated in calcium content when compared with that of the sample CTLB (% wheat flour bread) showing positive effect of additions of *Moringa oleifera* seed flour in the flour blends. This result is in line with the report of Igbabul *et al.* (2018) [11]. Highest improvement on calcium content was observed in bread sample NSPB with a value of 116.49 mg/100g while sample CTYB recorded lowest in improvement with a value of 113.30 mg/100g that was still significantly ($p<0.05$) higher than value of control sample (112.40 mg/100g). Adequate calcium intake is essential for normal development and maintenance of bones and teeth, clotting of blood, normal functioning of the heart and muscle, nerve irritability, and enzyme activation (Ihekoronye and Ngoddy, 1985; Inyang *et al.*, 2018) [13, 14]. Rickets, retarded growth, tetany and osteoporosis in older people surviving from diabetes have been linked to calcium deficiency (Ihekoronye and Ngoddy, 1985; Igbabul *et al.*, 2018) [13, 11].

There were significant ($p<0.05$) improvements in the iron contents of the composite bread samples that ranged from 1.81 mg/100g in sample CTLB (100% wheat flour bread) to 2.81 mg/100g in sample NSPB. This could be linked to the positive effects of additions of *Moringa oleifera* seed flour to the flour blends. From the results, significant ($p<0.05$) difference did not exist between bread samples of wheat flour, native starch, *Moringa oleifera* seed flour blends, and those of wheat flour, physically modified starch, *Moringa oleifera* seed flour blends for all the botanical sources (i.e white yam, trifoliate yam and sweet potato). In the case of chemical modification using acetylation, significant ($p<0.05$) difference existed between bread samples of wheat flour, native starch, *Moringa oleifera* seed flour blends, and those of wheat flour, chemically modified starch, *Moringa oleifera* seed flour blends for all the botanical sources (i.e white yam, trifoliate yam and sweet potato). Then for bread samples of physically (HMT) modified starches and those of chemically (acetylated) modified starches, significant ($p<0.05$) difference did not exist for all the botanical sources (white yam, trifoliate yam and sweet potato). Then comparing iron contents of the bread samples among the three botanical sources (i.e white yam, trifoliate yam and sweet potato), bread samples of sweet potato sources significantly ($p<0.05$) improved better than those of white yam and trifoliate yam sources in all the three categories of modification methods (i.e native, physical and chemical). Iron is essential for the formation of hemoglobin of red blood cells (Ihekoronye and Ngoddy, 1985; Inyang *et al*., 2018) [13, 14]. Iron deficiency in our diet leads to anemia that is characterized by weakness, dizziness and loss of weight (Inyang *et al*., 2018) [14].

Magnesium content in the bread samples significantly ($p<0.05$) decreased from 58.15 mg/100g in control sample CTLB to 55.85 mg/100g in bread sample PWYB. The result showed negative effect of incorporation of *Moringa oleifera* seed flour on the magnesium contents of the composite bread samples. The results are in agreement with the report of Inyang *et al*. (2018) [14]. That indicated reduced magnesium contents in composite flour cookies. Magnesium is needed for healthy muscles and nerves metabolism. Magnesium deficiency in our diet will lead to mental, emotional and muscle disorders. Magnesium in the diet affects the metabolism of calcium, potassium and sodium (Inyang *et al*., 2018) [14]. It is important for bone health and it is also needed as a cofactor for numerous reactions in the body. Comparing among the three starch sources, composite bread samples of sweet potato origin significantly ($p<0.05$) decreased least in magnesium contents while those of white yam origin significantly ($p<0.05$) decreased most.

Phosphorus contents of the bread samples varied significantly ($p<0.05$) from 63.88 mg/100g in sample CTLB (control) to 66.91 mg/100g in sample NTYB. All the composite breads had significantly higher phosphorus content than the control sample CTLB due to the incorporation of *Moringa oleifera* seed flour (good source of phosphorus) in their flour blends (Sahay *et al*., 2017) [31]. Among the starch sources, bread samples of trifoliate yam starch, significantly ($p<0.05$) maintained lead values in phosphorus contents while bread samples of white yam starch toddled for all the three categories- native, physical modification and chemical modification: 66.91 mg/100g (NTYB) > 66.36 mg/100g (NSPB) > 65.34 mg/100g (NWYB); 66.73 mg/100g (PTYB) > 66.07 (mg/100g PSPB) > 65.10 mg/100g (PWYB); 66.51 mg/100g (CTYB) > 65.72 mg/100g (CSPB) > 64.85 mg/100g (CWYB). For modifications, bread samples of both physically (HMT) and chemically modified starches had lower values of phosphorus contents when compared with those of native starches for all the three botanical sources. Functions of phosphorus in our body include normal development and maintenance of bones and teeth, metabolism of carbohydrate and fats, normal cell and muscle activities, and maintenance of normal acid-base balance of the blood (Ihekoronye and Ngoddy, 1985) [13]. People with phosphorus deficiency, could suffer retarded growth, poor tooth and bone formation, rickets, weakness, anorexia and pain in bones. This result is in agreement with the findings of Salguero *et al.* (2017) that reported increased phosphorus contents in composite cookies of carrot, lupine and barley.

Vitamin compositions of the bread samples made from the flour blends

The results of the vitamin compositions of the bread samples made from wheat flour, native/modified starch and *Moringa oleifera* seed flour blends are presented in Table 5

Table 5: Vitamin compositions of bread samples made from wheat flour, native/modified starch and *Moringa oleifera* seed flour blends

Bread Sample	Vitamin A (µg/g)	Vitamin B_1 (mg/100g)	Vitamin B_2 (mg/100g)	Vitamin B_3 (mg/100g)	Vitamin B_6 (mg/100g)	Vitamin C (mg/100g)
CTLB	1.840 ± 0.000^{g}	0.036 ± 0.001^{h}	0.065 ± 0.000^{f}	0.170 ± 0.00^{g}	0.210 ± 0.028^{h}	11.380 ± 0.000^{f}
NWYB	2.410 ± 0.028^{e}	0.049 ± 0.001^{e}	0.081 ± 0.003^{c}	0.280 ± 0.028^{cd}	0.330 ± 0.000^{def}	12.750 ± 0.071^{c}
NTYB	2.750 ± 0.000^{d}	0.058 ± 0.001^{bc}	0.085 ± 0.000^{c}	0.350 ± 0.000^{b}	0.360 ± 0.014^{cd}	13.050 ± 0.000^{b}
NSPB	3.980 ± 0.000^{a}	0.067 ± 0.001^{a}	0.096 ± 0.003^{a}	0.400 ± 0.014^{a}	0.440 ± 0.028^{a}	13.560 ± 0.085^{a}
PWYB	2.180 ± 0.028^{f}	0.045 ± 0.000^{f}	0.073 ± 0.003^{d}	0.240 ± 0.014^{ef}	0.290 ± 0.000^{fg}	12.500 ± 0.141^{d}
PTYB	2.520 ± 0.028^{e}	0.053 ± 0.001^{d}	0.081 ± 0.000^{c}	0.290 ± 0.000^{c}	0.340 ± 0.000^{cde}	12.800 ± 0.000^{c}
PSPB	3.790 ± 0.057^{b}	0.061 ± 0.001^{b}	0.093 ± 0.003^{ab}	0.360 ± 0.028^{b}	0.410 ± 0.028^{ab}	13.25 ± 0.212^{b}
CWYB	2.090 ± 0.099^{f}	0.041 ± 0.001^{g}	0.069 ± 0.001^{ef}	0.210 ± 0.014^{f}	0.260 ± 0.014^{g}	11.950 ± 0.071^{e}
CTYB	2.440 ± 0.000^{e}	0.047 ± 0.028^{ef}	0.076 ± 0.003^{d}	0.250 ± 0.000^{de}	0.310 ± 0.014^{ef}	12.350 ± 0.000^{d}
CSPB	3.580 ± 0.085^{c}	0.057 ± 0.000^{c}	0.090 ± 0.000^{b}	0.310 ± 0.014^{b}	0.380 ± 0.028^{bc}	13.050 ± 0.000^{b}

Values are mean± standard deviation of triplicate determinations

Values with different superscripts within the same column are significantly different at ($P<0.05$).

KEY: CTLB = Bread of 100%Wheat flour (Control)

NWYB= Bread of composite flour (85% wheat flour: 10% native white yam starch: 5% Moringa oleifera seed flour)

NTYB = Bread of composite flour (85% wheat flour: 10% native trifoliate yam starch: 5% Moringa oleifera seed flour)

NSPB = Bread of composite flour (85% wheat flour: 10% native sweet potato starch: 5% Moringa oleifera seed flour)

PWYB = Bread of composite flour (85% wheat flour: 10% physically modified white yam starch: 5% Moringa oleifera seed flour)

PTYB = Bread of composite flour (85% wheat flour: 10% physically modified trifoliate yam starch: 5% Moringa oleifera seed flour)

PSPB = Bread of composite flour (85% wheat flour: 10% physically modified sweet potato starch: 5% Moringa oleifera seed flour)

CWYB = Bread of composite flour (85% wheat flour: 10% chemically modified white yam starch: 5% Moringa oleifera seed flour)

CTYB = Bread of composite flour (85% wheat flour: 10% chemically modified white yam starch: 5% Moringa oleifera seed flour)

CSPB = Bread of composite flour (85% wheat flour: 10% chemically modified white yam starch: 5% Moringa oleifera seed flour

The results of the vitamin contents of the composite bread samples made from wheat flour, native/modified starch and *Moringa oleifera* seed flour blends are presented in Table 5. The vitamin A contents of the bread samples significantly ($p<0.05$) increased from 1.840 µg/g in control sample CTLB (100% wheat flour bread) to 3.980 µg/g in composite bread sample NSPB. The significant ($p<0.05$) improvements in vitamin A contents of the composite bread samples from the 100% wheat flour bread (CTLB) observed is attributed to the substitution effects of wheat flour with *Moringa oleifera* seed flour which is rich in vitamin A (Sengev *et al*., 2013; Gopalakrishnan *et al*., 2016; Chatepa and Mbewe, 2018; Igbabul *et al*., 2018) [34, 10, 3, 11]. Composite bread samples of sweet potato starch had highest improved vitamin A contents in native, physically modified and chemically modified starches categories, while those of white yam starch had lowest improvements. This could be ascribed to the rich vitamin A content of sweet potato (Igbabul *et al*., 2014; Mohanraj and Sivasankar, 2014) [12, 23]. Composite bread of native starches had highest values of vitamin A contents while composite bread samples of chemically modified starches had lowest values of vitamin A contents for all the three starch sources. Vitamin A is essential for good vision, growth and repair of body tissues, integrity of white and red blood cells, maintenance of the stability of cell membranes, and immunity of the body (Ihekoronye and Ngoddy, 1985; Donaldben *et al*., 2019) [13, 7]. It also promotes healthy skin, hair, nails, gums, glands, bones and teeth; and may help prevent lung cancer. Vitamin A deficiency is the cause of some of the major public health concerns ravaging developing countries like Nigeria. Functional disorders of the eye (night blindness), increased susceptibility to infections, changes in skin and membranes are symptoms of Vitamin A deficiency. Dietary intake of such composite breads fortified with Vitamin A can be a panacea to such global health concern.

Vitamin B_1 (thiamine) content significantly ($p<0.05$) improved from 0.036 mg/100g in bread sample CTLB (100% wheat flour bread) to 0.067 mg/100g in composite bread sample NSPB due to the additions of *Moringa oleifera* seed flour in the composite flours (Chatepa and Mbewe, 2018) [3]. The result is in agreement with the report of

Donaldben *et al*. (2019) [7]. That observed improved vitamin B_1 contents in composite cookies produced from wheat, *acha* and sprouted soybeans flour blends. Composite breads of modified starches were observed to have relatively low contents of vitamin B_1 to those of the native starches irrespective of the botanical source. In terms of starch source, sweet potato remained the most improved in thiamine content while white yam remained the least improved which could be attributed to the rich vitamin B_1 content of sweet potato. Vitamin B_1 is a water-soluble vitamin that plays vital role in metabolizing carbohydrates, formation of coenzyme, digestion, maintaining normal appetite and nervous system functions. Loss of appetite, irritability, less resistance to fatigue and constipation are linked to deficiency of vitamin B_1

The vitamin B_2 (riboflavin) contents in the bread samples ranged significantly ($p<0.05$) from 0.065 mg/100g (CTLB) to 0.096 mg/100g (NSPB). The results revealed significant ($p<0.05$) improvements in vitamin B_2 contents of all composite bread samples from control sample (CTLB) with exception to bread sample CWYB which still improved, but insignificantly ($p<0.05$) from control sample. Incorporation of *Moringa oleifera* seed flour in the composite flour blends is the key factor driving the increment of vitamin B_2 contents in the composite bread samples (Sahay *et al*., 2017; Chatepa and Mbewe, 2018) [31, 3]. The composite breads of sweet potato starches still maintained the lead positions while those of white yam starches toddled at the three categories of native, physical modification and chemical modification. In terms of modifications, composite bread samples of native starches had the best performances while those of modified starches had least performances. Vitamin B_2 is essential for healthy eyes and mouth tissue; and in formation of coenzyme needed in metabolism of carbohydrate, fat, and protein (Ihekoronye and Ngoddy, 1985) [13]. Deficiency symptoms of vitamin B_2 include cheilosis, blurred vision and light intolerance.

Vitamin B_3 (Niacin) contents of all the composite bread samples produced were significantly ($p<0.05$) higher than that of the control sample (CTLB) as a resultant effect of inclusions of *Moringa oleifera* seed flour in their flour blends (Bolarinwa *et al*., 2017). The composite bread sample NSPB had the highest value of 0.400 mg/100g of vitamin B_3 content while bread sample CTLB (100% wheat flour bread) had the lowest value of 0.170 mg/100g. Composite bread samples of modified starches were observed to have significantly ($p<0.05$) and relatively low contents of vitamin B_3 (niacin) to those of the native starches in all the three botanical sources. In terms of starch source, sweet potato remained the most improved in vitamin B_3 (niacin) content while white yam remained the least in improvement. Vitamin B_3 has been identified to be important in formation of coenzyme used in energy metabolism, supporting health of skin, nervous system and digestive system. Intake of high (pharmacological) doses of vitamin B_3 can help lower cholesterol in the body.

The result shows that supplementation of the flour blends with *Moringa oleifera* seed flour, significantly ($p<0.05$) beefed up the vitamin B_6 (pyridoxine) contents of the composite bread samples from 0.210 mg/100g (CTLB) to 0.440 mg/100g (NSPB). The composite bread samples of sweet potato starches took the lead positions in the vitamin B_6 contents while those of white yam starches lagged behind at all the three categories of native, physical modification and chemical modification. This is attributable to the rich source of vitamin B_1 by sweet potato (Igbabul *et al*., 2014) [12]. Then, comparing among native, physically and chemically modified starches, composite bread samples of native starches had the best performances while those of chemical modified starches had lowest values. Vitamin B_6 forms part of a coenzyme that helps the body synthesize non-essential amino acids and red blood cells; and also plays vital role in carbohydrate and protein metabolism. Supplementation of the composite flour blends with *Moringa oleifera* seed flour resulted in the significant ($p<0.05$) fortifications of all the composite bread samples with vitamin C (ascorbic acid). This result is in line with the report of Sahay *et al*. (2017) [31]. and Igbabul *et al*. (2018) [11]. that reported *Moringa oleifera* as rich source of vitamin C. The composite bread sample NSPB had the highest value of 13.560 mg/100g in vitamin C while the bread sample CTLB (100% wheat flour bread) had the lowest value of 11.380 mg/100g. From the results, composite breads of modified starches were relatively low in ascorbic acid to those of the native starches for the three selected starch sources. In comparing among the three starch sources, bread samples of sweet potato starches were the most improved in vitamin C contents while breads of white yam starches remained the least fortified with vitamin C. This trend could be traceable to the rich vitamin C contents of sweet potato (Igbabul *et al*., 2014) [12]. Ascorbic acid (vitamin C) is a water-soluble vitamin that is essential in collagen formation and maintenance (strengthens blood vessels, forms scar tissue, is a matrix for bone growth); healthy gums; prevention of atherosclerosis; serving as key antioxidant; strengthening resistance to infections; and improving absorption of iron. Scurvy, sore gums and high bruising tendencies are implicated deficiency symptoms of vitamin C.

Physical properties of the bread samples made from the different flour blends.

Results of the physical properties of composite bread samples made from wheat flour, native/modified starch and *Moringa oleifera* seed flour blends are presented in Table 6.

Table 6: Physical properties of the composite bread samples made from wheat flour, native/modified starch and *Moringa oleifera* seed flour blends

Bread sample	Height(cm)	Volume (cm^3)	Mass (g)	Specific volume (cm^3/g)
CTLB	8.57 ± 0.21^{a}	856.00 ± 1.00^{a}	325.27 ± 1.36^{a}	2.03 ± 0.75^{a}
NWYB	6.97 ± 0.15^{c}	682.87 ± 1.86^{c}	298.33 ± 1.25^{c}	1.90 ± 0.72^{a}
NTYB	5.23 ± 0.15^{f}	330.33 ± 1.53^{i}	260.10 ± 0.69^{j}	2.08 ± 0.49^{a}
NSPB	5.73 ± 0.21^{de}	325.67 ± 2.08^{j}	270.80 ± 0.61^{i}	2.01 ± 0.38^{a}
PWYB	5.53 ± 0.15^{e}	487.00 ± 2.00^{g}	281.83 ± 2.06^{g}	2.15 ± 0.38^{a}
PTYB	6.00 ± 0.10^{d}	515.67 ± 0.10^{f}	276.67 ± 1.17^{h}	2.20 ± 0.30^{a}
PSPB	7.00 ± 0.20^{c}	656.33 ± 2.52^{d}	290.80 ± 2.10^{e}	1.81 ± 0.51^{a}
CWYB	7.90 ± 0.20^{b}	552.33 ± 2.52^{e}	293.90 ± 3.15^{d}	1.48 ± 0.34^{a}
CTYB	8.13 ± 0.15^{b}	720.33 ± 2.52^{b}	315.60 ± 2.13^{b}	1.60 ± 0.56^{a}
CSPB	7.05 ± 0.13^{c}	374.00 ± 3.61^{h}	287.53 ± 0.97^{f}	1.58 ± 0.58^{a}

Values are mean± standard deviation of triplicate determinations

Values with different superscripts within the same column are significantly different at ($P<0.05$).

KEY: CTLB = Bread of 100%Wheat flour (Control)

NWYB = Bread of composite flour (85% wheat flour: 10% native white yam starch: 5% Moringa oleifera seed flour)

NTYB = Bread of composite flour (85% wheat flour: 10% native trifoliate yam starch: 5% Moringa oleifera seed flour)

NSPB = Bread of composite flour (85% wheat flour: 10% native sweet potato starch: 5% Moringa oleifera seed flour)

PWYB = Bread of composite flour (85% wheat flour: 10% physically modified white yam starch: 5% Moringa oleifera seed flour)

PTYB = Bread of composite flour (85% wheat flour: 10% physically modified trifoliate yam starch: 5% Moringa oleifera seed flour)

PSPB = Bread of composite flour (85% wheat flour: 10% physically modified sweet potato starch: 5% Moringa oleifera seed flour)

CWYB = Bread of composite flour (85% wheat flour: 10% chemically modified white yam starch: 5% Moringa oleifera seed flour)

CTYB = Bread of composite flour (85% wheat flour: 10% chemically modified white yam starch: 5% Moringa oleifera seed flour)

CSPB = Bread of composite flour (85% wheat flour: 10% chemically modified white yam starch: 5% Moringa oleifera seed flour)

The heights of the bread samples significantly ($p<0.05$) decreased from 8.57 cm in control bread sample (CTLB) to 5.23 cm in composite bread sample NTYB. All composite breads significantly ($p<0.05$) had reduced bread heights from that of the control sample CTLB (100% wheat flour bread) due to their reduced gluten contents as a result of substitution effects on the flour blends (Sengev *et al*., 2013; Iwe *et al*., 2014) [34, 15]. Studies reveal that partial replacements of wheat flour with non-glutinous flours lead to lower bread heights (Ocheme *et al*., 2010; Sengev *et al*., 2013) [25, 34]. The results showed that the increased proportions of non-glutinous (non-wheat) flours in flour blends generally affected the heights and shapes of breads. However, among the composite bread samples, CTYB and CWYB significantly ($p<0.05$) had the highest loaf heights of 8.13 cm and 7.90 cm respectively. These composite breads (CTYB and CWYB) which did not differ significantly ($p<0.05$) were of chemically modified (acetylated) starches of trifoliate yam and white yam respectively, and could compete favourably in loaf heights with that of control sample CTLB (100% wheat flour bread). Comparing loaf heights of the composite bread on the basis of effect of starch modifications, chemical modification (acetylation) led to highest improved loaf heights.

The loaf volumes of the breads significantly ($p<0.05$) ranged from 325.67 cm^3 in composite bread sample NSPB to 856.00 cm^3 in control sample CTLB. All composite breads had loaf volumes significantly ($p<0.05$) lower than that of control sample CTLB (100% wheat flour bread) due to supplementations with non-glutinous flours in their flour blends. The decreased loaf volumes observed in composite breads were caused by the reductions in wheat protein (gluten) contents of their flour bends. The higher the gluten content of flour, the higher the ability of the flour to extend (elasticity) and retain the carbon dioxide produced during fermentation (proofing) thereby yielding a higher loaf volume. Surprisingly, it is important to note that composite bread sample NSPB had the highest protein content but yet had the least loaf volume. This observation confirms the fact that flours' performance on breadmaking does not depend only on the protein quantity but also on protein quality. Similar observations had been reported by Ocheme *et al.* (2010) [25]. On the depression effects of substitution of wheat flour, on the loaf volumes of composite breads. Amongst the composite breads, bread sample CTYB had the highest loaf volume of 720.33 cm^3 which could compete favourably with that of the control sample CTLB of 856.00 cm^3. Loaf volume is very important bread characteristic providing a quantitative measurement of baking performance (Sengev *et al.*, 2013) [34]. And thus most consumers prefer breads with high volume and low density. The masses of the bread samples varied significantly ($p<0.05$) between 325.27 g in control bread sample (CTLB) and 260.10 g in composite bread sample NTYB. All the composite bread samples significantly ($p<0.05$) had lower masses than that of the control sample CTLB. The result is in disagreement with the reports of Nwosu *et al.* (2014) [24]. who reported increased masses of composite breads due to substitution effects. Loaf mass indicates the amount of moisture and carbon dioxide diffused out of the bread loaf during baking. The decreased masses of composite breads could be due to poor gluten network or frameworks of their dough as a result of their low gluten contents. This poor structure of the bread dough aided poor retention capacity of carbon dioxide by the composite breads leading to subsequent decrease in masses of composite breads. Amongst the composite breads, CTYB had the highest mass of 315.60 g which showed relatively improved visco-elastic properties of its dough. In Nigeria, appearance, weight and volume are common indices for bread acceptability by consumers.

The specific volumes of the breads insignificantly ($p<0.05$) ranged from 1.48 g/cm^3 in CWYB to 2.15 g/cm^3 in PWYB. Specific volume which is the ratio of volume of bread loaf to mass of bread loaf is adopted as a more reliable measurement of loaf size (Shittu *et al*., 2007) [35]. From the results, all the composite bread samples had good bread expansions since their specific volumes did not significantly differ from specific volume of control bread sample (CTLB). This suggests that the composite flours has increased hydrophilic and hydrophobic potentials that support volume increase traceable to their non-wheat flour fractions. Physical modification through heat moisture treatments of white yam starch and trifoliate yam starch might have enhanced the re-association of size–reduced starch molecules of amylose and/or amylopectin in amorphous regions and thus enhanced the baking expansions to the values of 2.15 cm^3/g and 2.20 cm^3/g respectively (Okereke, 2012; Iwe *et al*., 2014) [26, 15].

Sensory Properties of the Bread Samples

Results of the sensory properties of composite bread samples made from wheat flour, native/modified starch and *Moringa oleifera* seed flour blends are presented in Table 7.

Table 7: Sensory scores of bread made from wheat flour, native/modified starch and *Moringa oleifera* seed flour blends

Bread sample	Appearance	Aroma	Taste	After-mouth feel	General acceptability
CTLB	7.46 ± 1.53^{ab}	6.75 ± 1.54^{ab}	6.96 ± 1.68^{a}	6.33 ± 1.66^{ab}	6.75 ± 1.85^{a}
NWYB	7.29 ± 1.30^{ab}	6.13 ± 1.73^{ab}	6.17 ± 1.63^{ab}	5.79 ± 1.98^{ab}	5.79 ± 2.22^{a}
NTYB	6.17 ± 1.61^{c}	5.92 ± 1.91^{b}	5.92 ± 1.89^{ab}	5.79 ± 1.74^{ab}	6.08 ± 2.00^{a}
NSPB	7.29 ± 1.30^{ab}	6.13 ± 1.73^{ab}	6.17 ± 1.63^{ab}	5.79 ± 1.98^{ab}	5.79 ± 2.23^{a}
PWYB	6.17 ± 1.61^{c}	5.92 ± 1.91^{b}	5.92 ± 1.89^{ab}	5.79 ± 1.74^{ab}	6.083 ± 2.00^{a}
PTYB	6.46 ± 1.89^{bc}	5.83 ± 1.97^{b}	5.63 ± 1.86^{b}	5.54 ± 2.23^{ab}	6.08 ± 1.95^{a}
PSPB	7.46 ± 1.35^{ab}	7.13 ± 1.23^{a}	6.96 ± 1.73^{a}	6.75 ± 1.57^{a}	6.71 ± 1.57^{a}
CWYB	6.83 ± 1.66^{abc}	6.38 ± 1.95^{ab}	5.29 ± 2.24^{b}	5.25 ± 2.44^{b}	5.75 ± 2.03^{a}
CTYB	7.58 ± 1.18^{a}	6.63 ± 1.74^{ab}	5.50 ± 2.04^{b}	5.25 ± 2.34^{b}	5.79 ± 1.87^{a}
CSPB	7.33 ± 1.86^{ab}	6.63 ± 1.97^{ab}	6.13 ± 1.78^{ab}	6.33 ± 1.66^{ab}	6.33 ± 1.52^{a}

Values are mean± standard deviation of triplicate determinations

Values with different superscripts within the same column are significantly different at ($P<0.05$).

KEY: CTLB = Bread of 100%Wheat flour (Control)

NWYB= Bread of composite flour (85% wheat flour: 10% native white yam starch: 5% Moringa oleifera seed flour)

NTYB = Bread of composite flour (85% wheat flour: 10% native trifoliate yam starch: 5% Moringa oleifera seed flour)

NSPB = Bread of composite flour (85% wheat flour: 10% native sweet potato starch: 5% Moringa oleifera seed flour)

PWYB = Bread of composite flour (85% wheat flour: 10% physically modified white yam starch: 5% Moringa oleifera seed flour)

PTYB = Bread of composite flour (85% wheat flour: 10% physically modified trifoliate yam starch: 5% Moringa oleifera seed flour)

PSPB = Bread of composite flour (85% wheat flour: 10% physically modified sweet potato starch: 5% Moringa oleifera seed flour)

CWYB = Bread of composite flour (85% wheat flour: 10% chemically modified white yam starch: 5% Moringa oleifera seed flour)

CTYB = Bread of composite flour (85% wheat flour: 10% chemically modified white yam starch: 5% Moringa oleifera seed flour)

CSPB = Bread of composite flour (85% wheat flour: 10% chemically modified white yam starch: 5% Moringa oleifera seed flour

The sensory scores for the appearance of the bread samples significantly ($p<0.05$) ranged from 6.17 to 7.58. Apart from composite bread samples PWYB and NTYB (with common score of 6.17) that significantly ($p<0.05$) scored lower than the control sample CTLB (7.46), all other composite breads did not significantly ($p<0.05$) differ from control bread sample. However, all the bread samples passed the appearance test.

Sensory scores for the aroma of the bread samples significantly ($p<0.05$) ranged from 5.83 in bread sample PTYB to 7.13 in sample PSPB. From the results obtained, control sample (CTLB) did not significantly ($p<0.05$) differ from any of the composite bread samples. Thus this indicated that incorporations of *Moringa oleifera* seed flours and native or modified starches to the flour blends yielded no significant ($p<0.05$) difference from 100% wheat flour bread. Besides, bread sample PSPB won superior score of 7.13 when compared to that of the control sample CTLB of 6.75.

The scores for the taste of the bread samples varied significantly ($p<0.05$) between 6.96 in both CTLB and PSPB; and 5.29 in CWYB. Composite bread samples of PSPB (6.96), NWYB (6.17), NSPB (6.17), CSPB (6.13), NTYB (5.92) and PWYB (5.92) did not significantly ($p<0.05$) differ from the control sample (CTLB). All the composite bread samples still scored above the pass mark for sensory taste.

There was no significant ($p<0.05$) difference between control sample (CTLB) and any of the composite bread samples in terms of after-mouth feel. The scores of the after-mouth feel for all the breads significantly ($p<0.05$) ranged from 5.25 in CWYB and CTYB to 6.75 in PSPB. However, composite bread sample PSPB was insignificantly ($p<0.05$) preferred to control sample CTLB, and also significantly ($p<0.05$) preferred to composite bread samples CWYB and CTYB.

Surprisingly, significant ($p<0.05$) difference was not observed among all the bread samples on general acceptability by the panelists. Sensory scores for general acceptability of the breads ranged insignificantly ($p<0.05$) from 5.71 in CWYB to 6.75 in CTLB. From the results (Table 14), all composite breads produced, were generally accepted irrespective of the incorporations of *Moringa oleifera* seed flours and native/modified starches of the selected root/tuber sources to their flour blends.

Conclusion

Native, physically modified (HMT) and chemically modified (acetylated) starches from white yam, trifoliate yam and sweet potato were developed and; utilized in wheat-*Moringa oleifera* seed flour based breads which were acceptable, nutritious and shelf-stable. The supplementation of the wheat flour-native/modified starch flour blends with *Moringa oleifera* seed flour significantly ($p<0.05$) improved the nutritional qualities of the composite breads made from them while the different native/modified starches incorporated, significantly ($p<0.05$) exhibited suitable baking potentials for composite flour technology in bakery products.

The development and utilizations of these starches from these roots and tubers will tremendously curtail the huge post-harvest losses that threaten food security; depletion of foreign exchange reserve traceable to huge importation of wheat flour, and also will promote the commercialization and industrial exploitations of these local roots and tubers, as well as create employment opportunities and contribute meaningfully to the economy of Nigeria. Besides, supplementation of wheat flour with *Moringa oleifera* seeds flour will complement the deficiency in essential nutrients, combat malnutrition and health concerns resulting from excessive consumption of wheat flour products and of course make these functional foods affordable to Nigerians.

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