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By Endrias Dako, Negussie Retta & Gulelat Desse
Addis Ababa University

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Strictly as per the compliance and regulations of :

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Abstract- This study was conducted to determine the possibility of blending selected sweet potato flour to wheat flour to produce breads and to evaluate nutritional, anti-nutritional factors, quality and sensory attributes of breads. Because of its potential source of nutrients compared to yellow and white sweet potato varieties, orange sweet potato cultivar was selected for bread making and six blending ratios of its flour with wheat flour (0:100, 5:95, 10:90, 15:85, 20:80 and 25:75) were designed. Functional properties of composite flour such as wet gluten and water absorption capacity was decreased and, increased respectively as blending ratio of sweet potato flour increases. Quality parameters of breads such as loaf size (volume, specific volume and height) were significantly decreased but loaf weight was increased as blending ratio of sweet potato flour increases. Increase sweet potato flour in blending ratio significantly increased the moisture, ash, fiber, carbohydrate, calcium, iron and zinc content of the breads and resulted in a decrease in the protein, fat, energy, phosphorus, phytate, phytate: calcium, phytate: iron, phytate: zinc and [phytate x calcium]: zinc molar ratios of the breads. Sensory attributes such as appearance, aroma, taste, mouth feel and overall acceptability indicated that control bread was more preferred by consumers than sweet potato flour supplemented breads. However, breads made up to using 15% sweet potato flour supplemented accepted by consumers (scored above like slightly range), this leads to the conclusion that nutritional improved, anti-nutritional reduced and consumer acceptable breads can be prepared by supplementing up to 15% SPF in WF.

Keywords: sweet potato, variety, proximate, mineral, anti-nutritional factors, breads, blending ratio, functional properties, quality parameters, sensory attributes.

I. Introduction

Bread is a food product basically formed from flour, water, salt and yeasts. Bread flour is commonly made from wheat but it can be produced from other cereals like maize, rye, barley, rice and non-grain plants. Flour is the major basic ingredient in bakery products. Due to its important characteristics, wheat flour is the main ingredient in most types of breads (Aboaba and Obakpolor, 2010). Bread contains a good source of nutrients, such as macronutrients (carbohydrates, protein and fat) and micronutrients (minerals and vitamins) that are essential for human health to all population. However, the nutrient contents of bread products are depend on the chemical composition and baking processes used (Mohammed *et al.,* 2008).

Bread mainly produced form wheat flour but it can also be produced from composite flour such as a mixture of wheat and non wheat flours or wholly non wheat flour (David, 1992). The use of composite flour is advantageous in bread making for developing countries as it promotes high-yielding native plant species, increases nutritional values and enhances domestic agriculture production (Jolaosho, 2010). The goal of earlier researcher with composite flours was to save the largest possible percentage of wheat flour in the production of certain baked products. However, recently some research findings had showed that composite flour in new product development was used to improve nutritional value and sensory quality of the final products (Ammar *et al.,* 2009; Mepba *et al.,* 2007; Shoukat *et al.,* 2006).

Development in technology and research area showed that composite flours of sweet potato processed in to different food products for various purposes. A variety of food products such as doughnuts, biscuits, cakes, breads, cookies, fried chips, ice cream, porridge, breakfast foods and weaning foods have been made from sweet potato composite flour (Greene *et al*., 2003 ; Truong and Ramesh, 2010). Sweet potato flour can serve as source of nutrients (carbohydrates, protein, dietary fiber, beta-carotene, minerals (Ca, P, Fe and K) and can also add natural sweetness, color and flavor to processed food products (Woolfe, 1992). Hence, the development of appealing processed products from sweet potatoes play a major role in raising awareness on the potential use of the crop around the world.

An increased consumption of dietary fiber in daily diet has been recommended by nutritionists to improve health. High dietary fiber content of food is one of the most important factors in terms of developing healthy diets to reduce the incidences of cardiovascular diseases, diabetes, obesity and reduction of glucose metabolism and promotion of the growth of beneficial gut micro flora (Brennan, 2005). Depending on varieties,

Author α: Areka Agricultural Center, P.O.Box, 79, Areka. e-mail:endriasd@yahoo.com.
Author σ ρ: Addis Ababa University, Faculty of Science, P.O.Box, 1176, Addis Ababa.

sweet potatoes are low in protein but rich in dietary fiber and carbohydrate content so a successful combination of sweet potato variety with high nutritive value with wheat flour for bread production would be nutritionally advantageous. Fiber is an important nutritional contributor of sweet potatoes in human diet. So that integration of wheat flour and sweet potato flour enhance the fiber content of bread and may have a significant effect on human health (Anton, 2008).Thus, the aim of this study was to determine the appropriate substitution level of selected sweet potato flour for wheat flour in bread making.

II. Materials and Methods

a) *Description of the sampling area and sampling methods*

Three sweet potato varieties with orange, yellow and white flesh colors were collected from Areka Agricultural Research Center (Figure 2.1). Wheat flour was obtained from KOJJ Food Processing Complex P.L.C. currently used for bread production. The other ingredients such as compressed yeast, powdered salt (NaCl) and improver were purchased from the local market in Addis Ababa.

A) Koka-6(Yellow) B) Falaha (White) C) Kulfo (Orange)

Figure 2.1 : Three sweet potato varieties with different storage root flesh colors

b) *Experimental study setting*

Breads were baked in Entoto Technical and Vocational Education Training (TVET) and A laboratory experiment was conducted at the laboratories of Addis Ababa University and Ethiopian Health and Nutrition Research Institute.

c) *Preparation of sweet potato flour*

Flour from sweet potato was prepared based on the method described by Adeleke and Odedeji (2010) and shown in figure 2.2

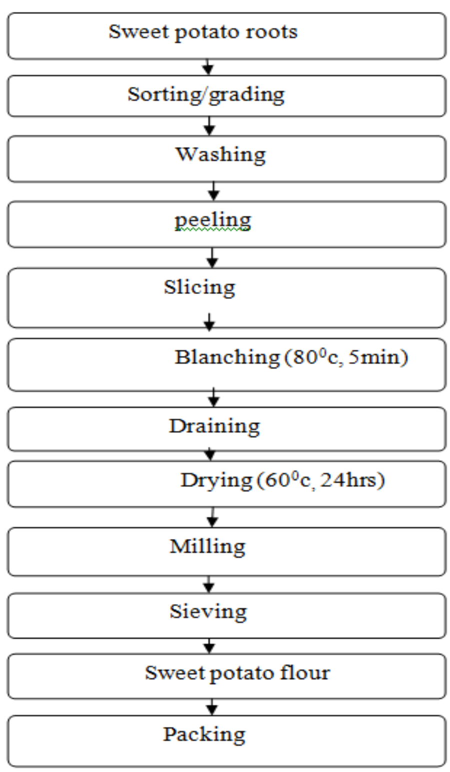

Figure 2.2 : Flow chart for the preparation of sweet potato flour

d) Preparation of composite flour

Six different blend proportions including control were designed (Table 2.1) based on the blend proportions used by Ifie (2011) in his bread formulated form sweet potato flour and wheat flour with slit modifications such that 5% and 10% more sweet potato flours are included in this blend preparation.

Table 2.1 : blending ratios of sweet potato flour and wheat flour in bread formulation

Sweet potato flour (%)	Wheat flour (%)
0	100
5	95
10	90
15	85
20	80
25	75

e) Bread preparation processes

Breads were formulated, prepared and baked based on the straight dough method used by Anton (2008) with slight modifications as the mixtures were mixed and kneaded with water in a flat wooden material manually instead of using electric mixer. Except water (variable) similar amount of all ingredients such as flour (100%), salt (1%), improver (1.5%) and yeast (2%) were used in each blend during the preparation of the dough (Table2.2). These ingredients in bread formulation were determined based on knowledge from traditional experienced bakers and literatures (Mepba *et al.,* 2007; Mardiana, 2008; Jolaosho, 2010; Ukpabi, 2010).

Table 2.2 : Ingredient used in dough formulation per loaf

Ingredient	Composition (%)
Flour	100
Yeast	2
Salt	1
Improver	1.5
Water	Variable

For bread baking, the straight dough method was used (Anton, 2008), all the ingredients were added at the same time (Figure 2.3) and mixed manually for 5 minutes and kneading was done until consistent dough was obtained. The resulted dough was left to rest for 20 minutes at room temperature (first proofing) then 100g piece of dough was divided, rolled and molded. Each piece was placed in metal pan and let to ferment for 45 minutes at room temperature (final proofing) then the baking process was carried out in electrically heated oven at 200^{0}C for 20 minutes. After baking loaves were separated from the metal pan and allowed to cool at room temperature before evaluation. The cooled loaves were dried at 60^{0}C for 9 hours and milled in to a fine powder using electric grinder (High-Speed sampling machine model- FW100) until to pass through 0.425mm sieve mesh size.

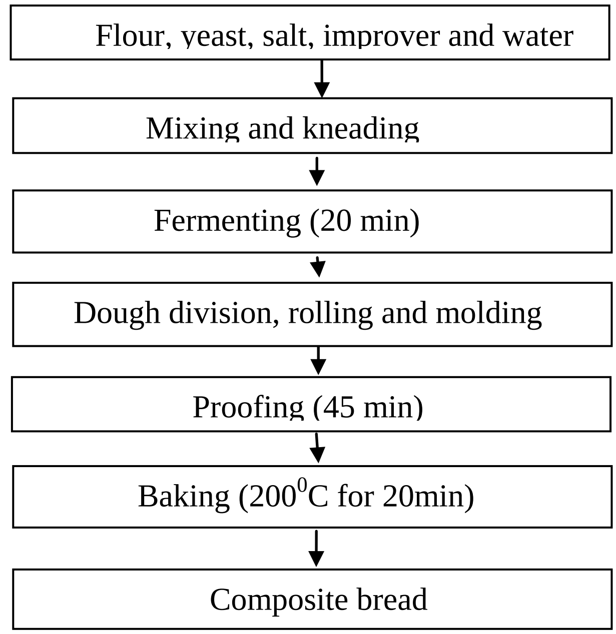

Figure 2.3 : Flow chart for bread making process

f) Methods of Analysis

i. *Determination of functional properties of composite flours*

Water absorption capacity was determined using the centrifuge method of Sosulki (1962) as cited in Edema *et al.* (2005). The gluten amount was evaluated by the standard methods of AACC test procedure (AACC, 2000).

ii. *Evaluation of bread quality parameters*

The loaf volume(VL) was measured by using seed displacement method (Mepba *et al.,* 2007) with slit modification using chickpea instead of barley seed. Loaf weight (W) of breads were measured after cooling for one hour on digital balance (Masood *et al.,* 2011). Specific loaf volume (VS) was calculated in the following expression:

$$\text{Specific Loaf Volume}(\text{cm}^3/\text{g}) = \frac{\text{VL}}{\text{W}}$$

iii. *Sensory evaluation of bread*

The sensory evaluation was carried out for consumer acceptance to evaluate loaf attributes such as appearance, aroma, taste, mouth feel and overall acceptability of the bread sample within two hours after baking. Twenty four panelists comprising of students and staff members from Food Science and Nutrition program of AAU and students and staff members of Hotel Management department in Entoto Technical and Vocational Education Training Institute (TVET) were randomly selected to perform the evaluation. Nine-point category scales was used to rate the attributes ranging from like extremely to dislike extremely as used by (Mepba *et al.,* 2007).

iv. *Proximate analysis*

The moisture content was determined according to AOAC (2000) using the official method 925.09 by oven drying. Crude fiber content was determined according to AOAC (2000) using official method 962.09. Protein content was determined according to AOAC (2000) using the official method 979.09. Total ash content was determined according to AOAC (2000) using the official method 923.03.The crude fat content was determined according to AOAC (2000) using official method 4.5.01. Total carbohydrate content was calculated by difference using the formula as follows:

Carbohydrate (%) = 100 – (% crude protein + % crude fiber + % total ash + % crude fat)

Total energy content was obtained using Atwater conversion factors 4, 9 and 4 for each gram of crude protein, crude fat and carbohydrate and expressed in calories, respectively (Guyot *et al*., 2007).

$$\text{Total energy}\left(\frac{\text{Kcal}}{100\text{g}}\right) = (9 \times \%\text{Fat}) + (4 \times \%\text{Protein}) + (4 \times \%\text{Carbohydrate})$$

g) *Mineral Analysis*

Calcium, magnesium, iron and zinc were determined according to the standard method of AOAC (2000) using an Atomic Absorption Spectrophotometer (Varian SAA-20 Plus). Phosphorus was determined using UV-VIS spectrometer

h) *Analysis of anti-nutritional factors*

Phytate content was determined using method described by Latta and Eskin (1980) and later modified by Vaintraub and Lapteva (1988).Tannin content was determined using the method of Burns (1971) as modified by Maxson and Rooney (1972).Oxalate content of sample was determined using method originally employed by Ukpabi and Ejidoh (1989).

i) *Statistical analysis*

The effect of blending ratio on nutritional, anti-nutritional and sensory attributes of breads was analyzed with one way ANOVA. Mean differences were statically significant at $p<0.05$ and the means of each parameter were compared using Duncan's multiple range test procedures to separate the means using SPSS, version 15.0 software.

III. Results and Discussions

a) *Functional properties of composite flours*

The mean wet gluten content of blends was significantly ($p<0.05$) decreased from 30.44 to 16.87g/100g for 100% wheat flour to 25% SPF in blending proportion, respectively (Table 3.1.). The highest (30.44g/100g) and lowest (16.87g/100g) mean wet gluten content was observed in 100% wheat flour and 25% blend of sweet potato flour, respectively. Generally, the mean wet gluten content was significantly ($P<0.05$) decreased as blending ratio of sweet potato flour increased. This means that the sweet potato-wheat flour blends significantly decrease gluten content; this is because of gluten is absent in sweet potato flour and as blending ratio increases the wet gluten content decreases. Similar ideas were reported by (Kun-Lun *et al.,* 2009; Hamed *et al.,* 1973).

Table 3.1 : Effect of blending ratio on functional properties of composite flours

Blending ratio	Wet gluten content (g/100g)	Water absorption capacity (ml/100g)
0%	30.44 ± 0.31^{a}	65.60 ± 0.42^{f}
5%	28.38 ± 0.15^{b}	73.20 ± 0.21^{e}
10%	25.24 ± 0.24^{c}	75.32 ± 0.13^{d}
15%	23.85 ± 0.12^{d}	81.60 ± 0.33^{c}
20%	19.88 ± 0.24^{e}	89.57 ± 0.23^{b}
25%	16.87 ± 0.09^{f}	91.61 ± 0.18^{a}

Reported values are the mean ±SE (n=3). Means with different letters in the same column are significantly different (P<0.05).

The mean water absorption capacity of sweet potato flour and wheat flour was 194.58ml/g and 65.60ml/100g, respectively. The mean water absorption value of control and blend flours ranged from 65.60-91.61ml/100g (Table3.1). Blending proportion significantly ($P<0.05$) affected water absorption capacity of flours. Generally, the mean water absorption capacity was significantly ($P<0.05$) increased as blending proportion of sweet potato flour increased. Similar outcomes were investigated by (El-Zainy *et al.*, 2010; Sukhcharn *et al.,* 2008). This increment in water absorption capacity as SPF increase in blend ratio might be contributed by sweet potato flour; because moisture content was low in sweet potato flour than wheat flour which increases water absorption capacity as more sweet potato flour was supplemented in blending ratio.

b) Evaluation of quality parameters of bread

Table 3.2 : Effect of blending ratio on quality parameters of breads

Blending ratio	Volume (cm^3)	Weight (g)	Specific volume (cm^3/g)	Height (cm)
0%	467.98± 1.80^a	84.09± 1.02^e	5.68± 0.08^a	5.77± 0.11^a
5%	461.08± 3.30^b	87.19 ± 0.53^d	5.29 ± 0.07^b	5.58 ± 0.04^a
10%	420.37 ± 2.90^c	89.32 ± 0.69^c	4.71± 0.06^c	4.92 ± 0.04^b
15%	357.87 ± 1.96^d	91.14± 0.17^b	3.93± 0.02^d	4.68± 0.10^c
20%	312.50± 1.48^e	92.79 ± 0.16^b	3.37 ± 0.12^e	4.22± 0.06^d
25%	260.47± 2.79^f	94.78 ± 0.15^a	2.75 ± 0.03^f	3.75 ± 0.03^e

Reported values are the mean ±SE (n=3). Means with different letters in the same column are significantly different (P<0.05).

The dough (100g) was weighed before baking and the breads were weighed after baking. Blending ratio was showed significant increase (P<0.05) in weight of loaves as sweet potato flour increases in blending (Table 3.2). This increment might be contributed by the higher water absorption capacity of sweet potato flour than that of wheat flour. These results were well agreed findings of (Hamed *et al.*, 1973; Greene and Bovel-Brenjamin, 2004).On the other hand, volume of loaves were significantly decreased (P<0.05) as sweet potato flour increased in blending(Table 3.2). The results in this study were agreed with other findings (El-Zainy *et al.*, 2010; Greene and Bovel-Brenjamin, 2004; Kun-Lun *et al.,* 2009; Hamed *et al.*, 1973).This is because sweet potato is soft with low gluten content and rich in fiber and thus the loaf reflect the gluten content of the bread The specific volume of breads was significantly (p<0.05) decreased as blending ratio of SPF to WF increased in breads(Table 3.2). This decrement in specific volume of breads can be resulted from decreased wet gluten content with increased supplementation of SPF on WF that results in increased loaf volume. Moreover the extra water absorption capacity of more SPF supplemented on WF those results in increased weight of final breads. Hence, specific volume is the ratio of loaf volume to loaf weight expected to be decreased. This result was agreed with El- Zainy *et al.* (2010).

Figure 3.1 : Breads made from wheat flour and wheat-sweet potato composite flour

A. Control (100%WF), B. 95% WF and 5% SPF,C. 90% WF and 10% SPF, D. 85% WF and 15% , E. 80% WF and 20% SPF, F. 75% WF and 25% SPF.

Blending ratio was caused a significant decrease (P<0.05) in an average loaf height of breads as sweet potato flour supplementation level increased in blending(Table 3.2). This observed reduction in loaf height as supplementation of WF with SPF increased might be contributed with less and less gluten level presence during dough formulation as more and more SPF was added in blending.

c) *Sensory analysis of breads*

Table 3.3 : Effect of blending ratio on sensory characteristics of breads

Blending ratio	Appearance	Aroma	Taste	Mouth Feel	Overall Acceptability
0%	7.92 ± 0.16^{a}	7.58 ± 0.16^{a}	7.46 ± 0.17^{a}	7.08 ± 0.18^{a}	7.17 ± 0.21^{a}
5%	7.42 ± 0.17^{ab}	7.25 ± 0.24^{ab}	7.13 ± 0.30^{ab}	6.88 ± 0.21^{a}	6.79 ± 0.28^{ab}
10%	6.88 ± 0.18^{b}	6.83 ± 0.24^{b}	6.83 ± 0.21^{ab}	6.00 ± 0.23^{b}	6.54 ± 0.20^{abc}
15%	6.08 ± 0.29^{c}	6.25 ± 0.30^{c}	6.67 ± 0.29^{bc}	5.88 ± 0.23^{bc}	6.17 ± 0.25^{bc}
20%	5.88 ± 0.19^{c}	6.33 ± 0.18^{c}	6.71 ± 0.21^{bc}	5.54 ± 0.27^{bc}	5.83 ± 0.23^{cd}
25%	5.75 ± 0.28^{c}	6.46 ± 0.27^{c}	6.33 ± 0.28^{c}	5.21 ± 0.28^{c}	5.38 ± 0.34^{d}

Reported values are the mean ±SE (n=24). Means with different letters in the same column are significantly different (P<0.05).

Table 3.3 shows that breads made at 15%, 20% and 25% sweet potato substitution levels were significantly (P<0.05) different in some of the attributes tested (appearance, aroma, taste and mouth feel) from the control bread hence control bread being more preferred by the panelists. However, at 5% and 10% SPF substitution levels there were no significant (P>0.05) difference in the mean acceptability of control bread and sweet potato supplemented breads. The panelists mean score test revealed that the control bread was scored higher in all the tested attributes. This does not mean that other bread samples were not acceptable, even at 25% substitution level the panelists seem to like the aroma and taste of bread produced from sweet potato and wheat flour blend. Despite the fact that control bread was more preferred to sweet potato supplemented breads, the average mean score of overall acceptability of up to 15% SPF composite breads are above 6 (like slightly) suggesting that they are acceptable range by consumers. This higher sensory attribute scoring for control bread compared with sweet potato and wheat flours composite breads could be due to the familiarization of the consumers to the normal wheat bread (Olaoye *et al*., 2006). This result was agreed with previous works of (Aniedu and Agugo, 2010; Greene and Bovell-Benjamin, 2004; Sukhcharn *et al.*, 2008).

d) *Nutritional composition*

i. *Nutritional composition of flours*

Table 3.4 : Chemical composition of sweet potato flour and wheat flour (on dry weight basis)

Constituents (%)	Wheat flour	Sweet potato flour
Moisture(g)	12.38 ± 0.04^{a}	8.37 ± 0.02^{b}
Protein(g)	11.63 ± 0.18^{a}	2.74 ± 0.01^{b}
Fat(g)	1.97 ± 0.02^{a}	1.12 ± 0.01^{b}
Crud Fiber(g)	1.83 ± 0.01^{b}	3.83 ± 0.04^{a}
Ash(g/100g)	0.78 ± 0.15^{b}	4.30 ± 0.03^{a}
Carbohydrate(g)	84.04 ± 0.18^{b}	88.00 ± 0.02^{a}
Total Energy (Kcal)	400.53 ± 0.14^{a}	373.00 ± 0.15^{b}
Calcium(mg)	27.41 ± 0.02^{b}	45.54 ± 0.01^{a}
Phosphorus(mg)	24.66 ± 0.01^{a}	20.68 ± 0.01^{b}
Iron (mg)	3.65 ± 0.02^{b}	11.46 ± 0.11^{a}
Zinc(mg)	0.69 ± 0.01^{b}	0.93 ± 0.01^{a}
Phytate(mg)	158.38 ± 0.24^{a}	77.74 ± 0.01^{b}

Reported values are the mean ±SE (n=3).
Means with different letters in the same rows are significantly different (p<0.05)

The mean values for proximate, minerals and phytate composition of wheat flour and sweet potato flour were calculated in 100g of flours and the obtained results are presented in Table 3.4. Sweet potato flour compared to wheat flour contains lower level of crude protein, crude fat, moisture, total energy and higher level of total ash, crude fiber and total carbohydrate content. Considering to minerals and phytate composition, sweet potato flour has higher level of calcium, iron and zinc and lower level of phosphorus and phytate than wheat flour. This result indicates that there is significantly compositional difference between sweet potato flour and wheat flour in their levels of proximate, minerals and phytate content. Therefore, blending of sweet potato flour to wheat flour will contribute to increase nutrients which were lower in one of the component of composite flours of breads.

ii. *Nutritional composition of breads*

a. *Proximate composition of breads*

Table 3.5 : Effect of blending ratio on proximate composition (g/100g) of breads

Blend ratio	Moisture*	Protein	Fat	Ash	Fiber	CHO**	T.E***
0%	30.77± 0.31^{f}	11.17± 0.01^{a}	1.73± 0.02^{a}	1.59± 0.01^{f}	1.76± 0.01^{f}	83.74± 0.01^{cd}	395.25± 0.17^{a}
5%	32.81± 0.04^{e}	10.86 ± 0.04^{b}	1.48 ± 0.03^{b}	1.82 ± 0.03^{e}	1.96± 0.01^{e}	83.87± 0.09^{c}	392.29± 0.29^{b}
10%	33.47 ± 0.02^{d}	10.66 ± 0.06^{b}	1.40± 0.04^{bc}	2.16 ± 0.04^{d}	2.22 ± 0.01^{d}	83.55 ± 0.03^{d}	389.47 ± 0.38^{c}
15%	34.90 ± 0.02^{c}	9.94± 0.02^{c}	1.36± 0.01^{cd}	2.40± 0.01^{c}	2.43± 0.01^{c}	83.88± 0.05^{c}	387.51± 0.06^{d}
20%	35.49± 0.03^{b}	9.31 ± 0.06^{d}	1.32 ± 0.02^{d}	2.58± 0.02^{b}	2.63± 0.02^{b}	84.16± 0.07^{b}	385.73± 0.22^{e}
25%	37.15± 0.03^{a}	8.34 ± 0.13^{e}	1.23 ± 0.02^{e}	2.83 ± 0.02^{a}	2.75± 0.01^{a}	84.85± 0.17^{a}	383.85± 0.08^{f}

*Reported values are the mean ±SE (n=3). Means with different letters in the same column are significantly different (P<0.05), *Wet basis, **Total carbohydrate, ***Total energy (Kcal/100g).*

The mean moisture content of breads ranged from 30.77-37.15g/100g (Table 3.5). Breads at 25% SPF substitution level had the highest mean moisture value (37.15g/100g) while the control one had the least value (30.77g/100g). Statistical analysis showed that the mean moisture content of all experimental breads were significantly increased ($p<0.05$) as substitution levels of sweet potato flour increased. This increment could be attributed to the water binding capacity of sweet potato flour. The present finding was consistent with reports of Aniedu and Agugo (2010).

Control bread had the highest mean protein content (11.17g/100g) while bread at 25% SPF substitution level had the least value (8.34g/100g) (Table 3.5). The mean protein content of breads were significantly decreased ($p<0.05$) as substitution levels of sweet potato flour increased. Low protein content was observed with all sweet potato supplemented breads compared to the control bread. This could be as a result of the low protein content in sweet potato flour than wheat flour. The present finding was consistent with reports of (Aniedu and Agugo, 2010; El- Zainy *et al*., 2010; Ifie, 2011).

Table 3.5 shows that the fat content of breads ranging from 1.23-1.73g/100g. Control bread had the highest mean fat content (1.73g/100g) while bread at 25% SPF substitution level had the least value (1.23g/100g). The mean fat content of breads were significantly decreased ($p<0.05$) as substitution levels of sweet potato flour increased. These reductions in fat content of breads observed in current study due to sweet potato flours contain low fat when compared to wheat flours. These results were well agreed with the findings of (Aniedu and Agugo, 2010; Ifie, 2011).

The mean fiber content of breads ranged from 1.76-2.75g/100g (Table 3.5). Control bread had the least mean fiber content (1.76g/100g) while bread at 25% SPF substitution level had the highest value (2.75g/100g). The mean fiber content of breads were significantly increased ($p<0.05$) as substitution levels of sweet potato flour increased. This increment in mean fiber content of breads could be due to the high quantity of fiber in sweet potato flour than that of wheat flour. The present findings were consistent with results of (Aniedu and Agugo, 2010; El- Zainy *et al*., 2010; Ifie, 2011).

The mean ash content of breads ranged from 1.59-2.83g/100g (Table 3.5). All blended breads had significantly higher ($p<0.05$) value of mean ash content when compared with the control bread. The effects of blend ratio was significantly increased ($p<0.05$) in mean ash content with SPF supplementation level on wheat flour increased. This increment in mean ash content of breads might be attributed by sweet potato flour; as sweet potato flour contains high ash level when compared to wheat flour. These results were in full agreement with results reported by (Aniedu and Agugo, 2010; El- Zainy *et al*., 2010; Ifie, 2011).

The mean carbohydrate content of breads ranged from 83.55-84.85g/100g (Table 3.5). The mean carbohydrate content of breads in this finding was increased even though some irregularity value was also happened. Control bread did not show significant difference ($p>0.05$) in carbohydrate content up to 15% SPF substitution level but was significantly different ($p<0.05$) with breads made up of 20% and 25% SPF substitution levels. The highest and lowest mean carbohydrate content were observed with breads supplemented at 25% SPF and 5% SPF levels, respectively. This increment might be attributed by sweet potato flour; as sweet potato flour contains high carbohydrate level when compared to wheat flour. A similar result had been reported by Ifie (2011).

The energy content of breads ranged from 383.85- 395.25Kcal/100g (Table 3.5). The energy content of breads was significantly decreased ($p<0.05$) with SPF substation level increased. This decrement in total energy of breads as the ratio of SPF increased in the blend, therefore, might be attributed by less energy content of sweet potato flour.

b. *Mineral content of breads*

The calcium content of breads ranged from 21.08-31.42mg/100g (Table 3.6). The calcium content of breads were significantly increased ($p<0.05$) as substitution levels of sweet potato flour increased. This could be due to high content of calcium in sweet potato flour than wheat flour. This result was consistent with finding of El- Zainy *et al.* (2010).

Table 3.6 : Effect of blending ratio on mineral composition of breads (mg/100g)

Blending ratio	Calcium	Phosphorus	Iron	Zinc
0%	21.08± 0.01[f]	19.23± 0.02[a]	2.92± 0.01[f]	0.52± 0.01[e]
5%	22.11± 0.01[e]	19.12 ± 0.01[b]	3.30± 0.01[e]	0.56 ± 0.01[ed]
10%	24.55 ± 0.02[d]	18.78 ± 0.02[c]	3.76± 0.02[d]	0.59 ± 0.01[cd]
15%	26.90 ± 0.01[c]	18.42± 0.02[d]	4.27± 0.01[c]	0.62± 0.02[bc]
20%	29.14± 0.01[b]	17.98 ± 0.01[e]	4.65 ± 0.02[b]	0.64± 0.02[b]
25%	31.42± 0.01[a]	17.51 ± 0.02[f]	5.09± 0.01[a]	0.68 ± 0.01[a]

Reported values are the mean ±SE (n=2). Means with different letters in the same column are significantly different (P<0.05)

The mean phosphorus content of breads ranged from 17.51-19.23mg/100g (Table 3.6). The phosphorus content of breads were significantly decreased (p<0.05) as substitution levels of sweet potato flour increased. This decrement in phosphorus level of breads as the ratio of SPF increased in the blend, therefore, might be attributed by less phosphorus content of sweet potato flour.

The mean iron content of breads ranged from 2.92-5.09mg/100g (Table 3.6). The iron content of breads were significantly increased (p<0.05) as substitution levels of sweet potato flour increased. Higher score of iron content was observed with all sweet potato supplemented breads compared to the control bread. This could be due to high content of iron in sweet potato flour than wheat flour. A similar result was observed by El- Zainy *et al.* (2010). Low level of zinc content was observed in all investigated breads and the mean value ranged from 0.52-0.68mg/100g. The mean zinc content of breads were significantly increased (p<0.05) as blending ratio of sweet potato flour increased. This could be due to high content of zinc in sweet potato flour than wheat flour; a similar result was investigated by El- Zainy *et al.* (2010).

The phytate content of breads was significantly decreased (p<0.05) with SPF substitution levels increased(Table 3.7). Control bread had the highest value of phytate (98.88mg/100g) and was significantly different (p<0.05) compared to all other SPF supplemented breads while bread supplemented with 25% SPF had the least value (67.43mg/100g). This decrease could be attributed to low level of phytate in sweet potato flour than wheat flour.

The phytate: calcium molar ratio of breads was significantly decreased (p<0.05) with SPF substitution levels increased(Table 3.7). Control bread had the highest value of phytate: calcium molar ratio (0.29) and was significantly different (p<0.05) compared to all other SPF supplemented breads while bread supplemented with 25% SPF had the least value (0.14). This decrease could be attributed to the low and high level of phytate and calcium in sweet potato flour than wheat flour.

The phytate: calcium molar ratios >0.24, indicative of poor calcium bioavailability (Norhaizan and Faizadatul, 2009). The phytate: calcium molar ratio in the present study for control and 5% SPF substituted breads were higher than the reported critical level; this indicates that absorption of calcium adversely affected by phytate in these breads. But in case of other breads (10%-25% SPF substituted breads) the value was lower than the reported critical level, which shows that absorption of calcium not affected by phytate in these breads.

Table 3.7 : Effect of blending ratio on phytate and phytate mineral molar ratios of breads

Blending ratio	Phytate (mg/100g)	Phy:Ca	Phy:Fe	Phy:Zn	[PhyxCa]:Zn (mg/100g)
0%	98.88±0.34[a]	0.29±0.01[a]	2.89±0.01[a]	18.82±0.41[a]	0.099±0.001[a]
5%	89.94±0.65[b]	0.25±0.01[b]	2.31±0.02[b]	16.03±0.10[b]	0.094±0.004[a]
10%	87.29±0.65[c]	0.22±0.01[c]	1.96±0.00[c]	14.67±0.05[c]	0.093±0.003[a]
15%	75.83±0.64[d]	0.18±0.01[d]	1.52±0.02[d]	12.12±0.49[d]	0.083±0.004[b]
20%	72.21±0.65[e]	0.16±0.01[e]	1.32±0.02[e]	11.19±0.19[de]	0.082±0.002[b]
25%	67.43±0.33[f]	0.14±0.01[f]	1.13±0.01[f]	10.25±0.05[e]	0.081±0.001[b]

Reported values are the mean ± SE (n=3). Means with different letters in the same columns are significantly different (P<0.05)

The phytate: iron molar ratio of breads was significantly decreased (p<0.05) with SPF substitution levels increased(Table 3.7). Control bread had the highest value of phytate: iron molar ratio (2.89) and was significantly different (p<0.05) compared to all other SPF supplemented breads while bread supplemented with 25% SPF had the least value (1.13). This decrease could be attributed to the low and high level of phytate and iron in sweet potato flour than wheat flour. The phytate: iron molar ratio >1, indicative of poor iron bioavailability (Norhaizan and Faizadatul, 2009). The phytate: iron molar ratio in the present study for all breads were higher than the reported critical value, which implies the absorption of iron from all experimental breads were found inhibited by phytate and as a result the bioavailability of iron is poor in these breads.

The mean phytate: zinc molar ratio of breads ranged from 10.25-18.82 (Table 3.7). The mean phytate: zinc molar ratio of breads was significantly decreased ($p<0.05$) with SPF substitution levels increased. Control bread had the highest value of phytate: zinc molar ratio (18.82) and was significantly different ($p<0.05$) compared to all other SPF supplemented breads while bread supplemented with 25% SPF had the least value (10.25). This decrease could be attributed to the low and high level of phytate and zinc in sweet potato flour than wheat flour. The phytate: zinc molar ratios >15, indicative of poor zinc bioavailability (Norhaizan and Faizadatul, 2009). The phytate: zinc molar ratio in the present study for control and 5% SPF substituted breads were higher than the reported critical level, indicating that absorption of zinc was found adversely affected by phytate in these breads. But in case of other breads (10%-25% SPF substituted breads) the value was found lower than the reported critical value, indicating that absorption of calcium was not affected by phytate in these breads.

The [phytate x calcium]: zinc molar ratio of breads ranged from 0.081-099mg/100g (3.7). Generally, the mean [phytate x calcium]: zinc molar ratio of breads was significantly decreased ($p<0.05$) with SPF substitution levels increased. This decrease could be attributed to the low and high level of phytate and zinc in sweet potato flour than wheat flour. The potential effect of calcium on zinc absorption in the presence of high phytate intakes has led to the suggestion that the [phytate x calcium]: zinc molar ratio may be a better index of zinc bioavailability than the phytate: zinc molar ratio alone (Obah and Amusan, 2009). High calcium levels in foods can promote the phytate-induced decrease in zinc bioavailability when the [phytate x calcium]: zinc molar ratio greater than 200mg/100g (Norhaizan and Faizadatul, 2009). In this study, the values of [phytate x calcium]: zinc molar ratios of all breads were found less than the reported critical level. Therefore, bioavailability of zinc is not affected by calcium in the presence of phytate levels in all experimental breads.

IV. Conclusion and Recommendations

The result of present study showed that supplementation of sweet potato flour to wheat flour greatly decreased dough stability and loaf size (volume, specific volume and height) due to the dilution of gluten matrix in wheat flour. Composite flours have lower level of wet gluten content and higher level of water absorption capacity than control(wheat) flour. Breads prepared from SPF supplemented had significantly increased levels of moisture, ash, fiber, carbohydrate, calcium, iron and zinc content than control(wheat) bread. This was due to the high levels of these nutrients in SPF compared to wheat flour. On the other hand, there was a decrease in protein, fat, energy and phosphorus levels of breads as substitution of SPF increased in blending ratio. Moreover, the phytate content and phytate mineral molar ratios of blended breads were also significantly decreased than control(wheat)bread. Thus, supplementation of SPF can reduce phytate level, enhance mineral bioavailability and improve nutritional status of wheat bread.

Nevertheless, all nutritionally rich food products may not be always desired to consumer acceptance. Results of sensory attributes in terms of appearance, aroma, taste, mouth feel and overall acceptability indicated that control bread was more preferred by consumers than SPF supplemented breads. However, breads made up-to using 15% SPF substituted level accepted by consumers (scored above like slightly range), this leads to the conclusion that nutritional improved, anti-nutritional reduced and consumer acceptable breads can be prepared by supplementing up to 15% level SPF in WF.

Based on the current study, it is recommended that breads production from sweet potato and wheat composite flours should be given emphasis and processors should be encouraged to utilize the potential nutrient source of sweet potato flour. Since such breads are a good source of dietary fiber, which may also be of benefit in the prevention of cardiovascular diseases and cancers. Since protein value is low in sweet potato cultivars, it is encouraged that sweet potato crop should be consumed along with legumes. Thus, farmers who cultivate sweet potato crop should also cultivate legumes in order to compensate protein value of sweet potato for their growing children.

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