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Nutritional and Physiochemical Properties of Tiger nut (*Cyperus esculentus*) and Orange Flesh Sweet Potato (*Ipomoea batatas*) Composite Flour

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ABSTRACT

Cereals have been the main source of flour utilized in the food industry for the production of various processed foods across the globe. However, in this study, the nutritional and physiochemical properties of various formulations of tiger nut and orange flesh flour were tested. Orange flesh sweet potato and the yellow type of tiger nut used were processed for the various flour formulations and quality assessment. The tiger nuts and orange flesh were dried using a solar drier and milled into flour. The flour from the tiger nut and the potato were formulated into three forms including; [1]100% tiger nut, [2]90% tiger nut: 10% orange flesh sweet potato, and [3]60% tiger nut: 40% orange flesh sweet potato. The mean proximate results of the three composite flour formulations (respectively) were carbohydrate (62.3%, 63.9% and 68.1%), crude fat (13.9%, 19.2% and 20.9%), protein (5.3%, 6.3% and 6.8%), fibre (3.6%, 3.7% and 3. 8%), ash (1.4%, 1.7% and 2.5%), and moisture (5.0%, 5.2% and 6.5%) as against mean percentages of 11.60-20.0%, 1.10-2.95%, 4.5-9.87%, 4.43%, 44.60-69.60%, and 2.10-26.70% for moisture, ash, protein, fat, carbohydrate and fibre respectively on maize. The energy value of the samples ranged from 418.7 - 464.8 Kcal making samples suitable for contributing to the daily energy requirements of consumers. The physiochemical properties ranged from 0.432-0.448 g/ml for loose density and 0.607-0.607 g/ml for tapped density, 26.26-29.66 for compressibility and 1.36-1.42 as hausner ratio. The water activity ranged from 0.55-0.56 and 202.11-172.43 were recorded for water absorption. In terms of nutritional quality, the 60% tiger nut: 40% orange flesh sweet potato flour was superior. However, the means scores for consumer acceptability of the porridge prepared from the formulated samples were not significantly different. Therefore, tiger nut and orange flesh sweet potato can be processed into flour for use in the food industry to supplement or replace the use of flour from cereals.

Keywords: Tiger nut**,** orange flesh sweet potato, composite flour, physiochemical properties, nutritional, sensory evaluation.

INTRODUCTION

There are high nutritious and quality food demands by consumers in Ghana due to life style changes, occupational and settlement demands. Exploring and diversifying the use of agricultural produce especially roots and tubers will help to reduce the level of cereal dependence for most consumers with gluten alleges. Tiger nut (*Cyperus esculentus*) is a grass-like plant which is cultivated for it sweet tuber or rhizome for human consumption (Ayo, 2018). It is called "Susuola" by the "Kusasis" and "Atadwe" by the "Akans". The nutritional value and it characteristics have made it a multipurpose crop. In Ghana tiger nut is being commercialised

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mostly by street hawkers by packaging them in plain polyethylene bags at lorry stations and toll boots. Tiger nut has a lot of health benefits such, reduces blood sugar, reduce weight, control blood pressure and many more and it is highly nutritive in fibre, proteins, sugars (glucose) and they are also good in oleic acid, phosphorus, vitamins (E and C), magnesium and potassium (Sánchez-Zapata *et al*., 2012). Tiger nut helps in reducing or preventing diabetes and cancer (Traders, 2016).

Orange flesh sweet potato (*Ipomoea batatas L. Lam*) is bio-fortified sweet potato which is gaining more significant and considerable in the food industries (Abidin *et al.*, 2015). Sweet potato is an important crop that can meet the financial and dietary needs of the consumers in developing countries such as Ghana (Carey *et al.*, 2014). It is rich in dietary fibre, minerals, vitamins A, and antioxidants such as phenolic acids, anthocyanin's, tocopherol and β-carotene (Mamo *et al*., 2014). Orange flesh sweet potato contain sufficient β-carotene which is Vitamin A forerunner capable of improving Vitamin A deficiency (VAD) (Hagenimana and Low, 2000).

Tiger nut and orange flesh sweet potato have a great potential uses for the food, cosmetics, pharmaceutical and animal feed industries.

The objective of the research was to produce composite flour from tiger nut and orange flesh sweet potato, determine it nutritional and physiochemical properties and evaluate consumer acceptability of porridge from the composite flour.

MATERIALS AND METHODS

Sample Collection, Processing and Formulation

Tiger nut (yellow variety) was purchased from Bono East Regional Capital (Techiman) and orange flesh sweet potato (OFSP) was obtained from orange flesh sweet potato farmers in the Northern Region (Kumbungu) of Ghana. The tiger nut and orange flesh sweet potato was sorted and washed with potable water to remove soil. The initial moisture content of the tiger nut was 13.04% and orange flesh sweet potato was 72.5%. Orange flesh sweet potato was peeled, sliced and treated with ascorbic acids of 30 g in 3 L of water to prevent it from browning. The nut and orange flesh sweet potato was dried using solar dryer for 30 hours at a temperature and relative humidity of 51.2°C and 40.0% respectively using a logger (HOBO ProV2). The moisture content of the dried tiger nut and orange flesh sweet potato was 6.03% and 6.78% respectively before milling using a burr mill for three consecutive times for tiger nuts and once for orange flesh sweet potato to get the flour. Flour from a sieve size of 250 µm was used for the formulation. Three sample were formulated (100% tiger nut, 90% tiger nut: 10% orange flesh sweet potato and 60% tiger nut: 40% orange flesh sweet potato) and each sum up to 100 g.

Determination of Nutritional and Physiochemical properties of Samples

Protein, fat, moisture, fibre and ash of the flour was determined using the methods of Analysis of the Association of Official Analytical Chemists, 15th edition (1990), while carbohydrate was determined by difference. The loose and tapped density was determine by the method of Adeleke and Odedeji, (2010) with slight modification. Fifty grams of the composite flour was measured into 100 ml graduated cylinders.

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The initial volume was recorded before tapping it on a table for 100 times. The compressibility and hausner ration was calculated. Water absorption capacities of the composite flour samples were determined by Adeleke and Odedeji, (2010) methods with slight modification. One gram of the flour was mixed with 10 ml of water in a centrifuge tube and allowed to stand at room temperature (28 ± 2°C) for 1 h. It was then centrifuged at 200 rpm for 30 minutes and water absorption capacity was calculated. The brix content of the composite flour was determined by using potable refractometer.

Sensory Evaluation of Prepared Porridge

Fifty (50) untrained panellists were randomly selected from Nyankpala Campus, University for Development Studies. Five point's hedonic scale with 1. disliked very much, 2. disliked moderately, 3. neither liked nor disliked, 4. liked moderately, 5. liked very much, was used to evaluate the products. The attributes that were assess include; mouth feel, taste, aroma, colour, thickness and overall acceptability. Evaluation score sheets were designed and the products were randomly coded to blindfold panellists from knowing the formulation being evaluated. The products were served in plain 40 ml polypropylene container and panellists asked to rinse their mouth with water after evaluating each product.

Statistical Analysis

The data obtained from the proximate (moisture, ash, crude fat, crude protein, crude fibre, energy and carbohydrate) and functional properties results were subjected to analysis of variance (ANOVA), while the sensory evaluation were analysed using Kruskal-Wallis in XLSTAT 2016. Turkey's test was used to compare and relate the differences between means at 5% level of significance ($P < 0.05$).

RESULTS AND DISCUSSION

Nutritional Composition of the Composite Flour

From the proximate composition results (Table 1), there were significant difference ($P<0.05$) between all samples for crude fibre. There was no significant difference between 100% tigernut and 90%tigernut:10% sweet potato composite samples for ash, carbohydrate, moisture content, crude fat and protein. There were however, significant differences between composite samples of 60% tigernut:40% sweet potato and the other two samples (100% tigernut and 90% tigernut:10% sweet potato) for ash, carbohydrate, moisture content, crude fat and protein. The energy content was not significantly different between samples 100% tigernut and 90% tigernut:10% sweet potato but was significantly different between sample 60% tigernut:40% sweet potato and the other two samples (100% tigernut and 90% tigernut:10% sweet potato). There was a general trend of increase in proximate percentages except for crude fat, protein and energy which could be attributed to an increased percentage in sweet potatoes. This finding affirms the chemical and nutritional value of maize and maize products by Enyisi *et al.* (2014), and Abiose and Ikujenlola (2014) on the comparison of chemical composition, functional properties and amino acids composition of quality protein maize and common maize (*Zea may* L) with fibre (2.100 – 26.70), carbohydrate (44.60 – 69.60), moisture

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(11.60 – 20.00), ash (1.10 – 2.95), crude fat (2.17 – 4.43), protein (4.50 – 9.87) and energy (357.00 – 358.50).

Table 1: Proximate Composition of tiger nut and orange flesh sweet potato composite flour

Samples	Tiger nut (100%)	Tiger nut (90%): OFSP (10%)	Tiger nut (60%): OFSP (40%)	p-value
Fibre (%)	3.62±0.02^{a}	3.69±0.02^{b}	3.77±0.016^{c}	0.002
Carbohydrate (%)	62.26±0.51^{a}	63.93±0.51^{a}	68.089±0.51^{b}	0.001
Moisture (%)	4.99±0.30^{a}	5.20±0.30^{a}	6.47±0.30^{b}	0.025
Ash (%)	1.36±0.13^{a}	1.69±0.13^{a}	2.45±0.13^{b}	0.002
Crude Fat (%)	20.93±0.51^{b}	19.21±0.51^{b}	13.89±0.51^{a}	<.001
Crude Protein (%)	6.84±0.21^{b}	6.27±0.21^{b}	5.34±0.21^{a}	0.007
Energy (kcal/100)	464.77±3.17^{b}	453.70±3.17^{b}	418.6813.17^{a}	<.001

*± represent standard error. Different superscript within rows indicate significant difference between means.

The fibre values obtained were higher than the values reported by Ade-Omowaye *et al*. (2008) on wheat-tiger nut composite flour and bread. There was an increase in carbohydrate content with decrease in tiger nut flour was supported by the findings on evaluation of tiger nut wheat composite flour and bread (Ade-Omowaye *et al*. 2008).

Moisture content of the composite flour was not different from the findings of Adekanmi *et al*. (2009), who also affirmed that moisture content could be influenced by processing techniques and its effect on the nutrients and antinutrients of tiger nut.

The ash content was increasing as orange fleshed sweet potato content increased in composition and this may be that the tiger nut contained less minerals content and orange-fleshed sweet potato contain high minerals content. The available crude fat content decreased as orange flesh sweet potato content increased was higher than the findings of Adejuyitan *et al*. (2009). The protein content decreased as the orange-fleshed sweet potato composition increased was in agreement with the research on the proximate composition of raw, soaked and toasted tiger nut (Adekanmi *et al*., 2009). The energy value increased with increased tiger nut composition and could be attributed to the high crude fat in tiger nut.

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Physiochemical and Functional Properties of Composite Flour

From the physiochemical and functional results (Table 2), the brix value of the tiger nut decreases as sweet potato content increased and this could be attributed to the increased sugar (carbohydrate content) in sweet potatoes. Water activity, water absorption capacity, bulk density (loose density), tapped density, compressibility and hausner ratio did not show any significance difference (P<0.05) between the samples.

Table 2: Physiochemical and Functional Properties of Composite Flour

Description	Tiger nut 60%: 40%OFSP	Tiger nut 90%: 10% OFSP	Tiger nut (100%)	p-value
Brix	40.133±0.48[a]	43.20±0.48[b]	48.67±0.48[c]	<.001
Temperature	26.53±0.17[b]	25.90±0.17[a]	25.57±0.17[a]	0.030
Water Activity	0.56±0.00[a]	0.56±0.00[a]	0.55±0.00[a]	0.376
Water Absorption Capacity (%)	202.11±4.41[b]	172.46±4.41[a]	172.43±4.41[a]	0.005
Loose Density	0.43±0.00[a]	0.45±0.00[a]	0.45±0.00[a]	0.096
Tapped Density	0.62±0.00[a]	0.61±0.00[a]	0.61±0.00[a]	0.380
Compressibility (%)	29.66±0.80[a]	27.29±0.80[a]	26.26±0.80[a]	0.066
Hausner Ratio	1.42±0.02[a]	1.38±0.02[a]	1.36±0.02[a]	0.064

*± represent standard error. Different superscript within rows indicates significant difference between means.

Water activity and temperature have effect on food spoilage. The water activity of the samples was below the 0.62 which makes it more stable and it will help to extend it shelf life. The bulk density (loose density) qualities of a flour depend on the method of producing and handling of the flour. The bulk density, tapped density, compressibility and hausner ratio helps to determine the flowability of the flour and the interaction of interparticulates (Jan *et al*., 2015). The bulk density and tapped density values were closer and it indicate free flow ability (Jan *et al*., 2015). The flowability scale provided by Igathinathane *et al*. (2010), on group samples with compressibility and hausner ratio of 26 and 1.35 and above respectively as a product with poor flow characteristics. The values obtained shows that the samples have poor flowability. The bulk density of this findings fall within the density database of cereals and cereals products (wheat flour, millet and biscuit) and also in lined with some root tubers such as sweet potato prepared by Charrondiere *et al*. (2011). The bulk and tapped density values were also in conformity with the work of Ajani *et al*. (2016).

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Colour Properties of the Composite Flour

The colour properties (Table 3) had effects on the appearance and attractiveness of a product. The hue angle is used to define the trait of colours as it has been known usually as reddish, yellowish, greenish (Wikipedia, 2019a). The higher the hue angle value, the lesser yellow characteristics of the sample, tiger nut 60%: 40% orange flesh sweet potato had the highest hue value, preceded by 100% tiger nut and tiger nut 90%:10% orange flesh sweet potato with the highest yellow trait. There were significant differences between all the samples except for 100% tiger nut flour and tiger nut 90%: 10% orange flesh sweet potato composite flour which was not significantly different for chroma. The difference could be attributed to the incorporated orange flesh sweet potato which had a lesser yellow colour trait.

Table 3: Colour properties of tiger nut-orange-fleshed sweet potato flour

Sample	L*	a*	b*	Chroma	Hue Angle
Tigernut 90%:10%OSFP	65.51±0.01[b]	22.00±0.43[c]	81.34±0.16[b]	84.26±0.26[b]	74.86±0.26[a]
100%Tigernut	65.07±0.01[a]	19.50±0.43[b]	80.97±0.17[b]	83.29±0.26[b]	76.46±0.26[b]
Tigernut 60%:40%OFSP	69.13±0.01[c]	3.76±0.43[a]	25.09±0.17[a]	25.37±0.26[a]	81.48±0.26[c]
p-value	<.001	<.001	<.001	<.001	<.001

*± represent standard error. Different superscript within columns indicate significant difference between means.

Higher chroma value indicate how humans perceives the intensity colour of the sample. The b* was used to measure the yellowness and the blueness colour of the product, when the value is positive it means the product have yellow colour but if it is negative, it is blue in colour. Samples tiger nut 90%: 10% orange-fleshed sweet potato had the highest yellow trait, followed by 100% tiger nut flour and tiger nut 60%: 40% orange-fleshed sweet potato. For a*, the values indicated the samples are very poor in red colour and could be attributed to the raw materials used. The L* measured the clarity or the lighteners of the colour of a substance, it measures from zero which indicate black to 100 which indicate white (Wikipedia, 2019b).

Sensory Evaluation of Porridge prepared from Composite Flour

From the sensory parameter scores (Table 4) there were no significant differences (P<0.05) among all the attributes. The mean scores for all attributes were liked moderately without the nutritional knowledge which could have influenced the product overall acceptability. General scores for thickness, aroma and colour were relatively higher than scores for taste, mouthfeel and overall acceptability.

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Table 4: Sensory Evaluation of Tiger Nut and Orange flesh Sweet Potato composite flour Porridge

Formulation	Attributes					
	Thickness	Aroma	Colour	Taste	Mouthfeel	Overall acceptability
100%Tigernut	3.86±1.05[a]	3.84±0.91[a]	3.94±0.86[a]	3.56±1.16[a]	3.66±0.98[a]	3.78±0.98[a]
Tigernut 90%:10% OFSP	3.94±0.94[a]	3.60±0.81[a]	3.90±0.93[a]	3.86±0.88[a]	3.62±0.88[a]	3.72±0.90[a]
Tigernut 60%:40% OFSP	3.86±1.09[a]	3.40±1.14[a]	3.80±1.03[a]	3.62±0.95[a]	3.80±0.93[a]	3.64±0.99[a]
p-value	0.984	0.088	0.850	0.321	0.578	0.713

*± represent standard error. Different superscript within column indicate significant difference between means.

CONCLUSION AND RECOMMENDATION

The formulations had significant nutritional composition and functional properties to support the nutritional needs of consumers. The compressibility, tapped density, water absorption and water activity were adequate for the classification of flour stability. Consumer acceptability of the porridge could supplement or replace the use of flour from cereals for consumers who are react to gluten. It is essential however, to make the product available and accessible for commercial use.

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