Evaluation of Mineral Composition and Water-Soluble Vitamin Contents of Flakes Made from Components of Local Rice, Water Yam, Soybean Composite Flours

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ABSTRACT

This study was carried out to evaluate the mineral composition and water-soluble vitamin contents of flakes made from local rice, water yam, and soy bean flour blends. The design used generated ten different mixtures. The mineral contents of flaked samples produced in this study were significantly (p<0.05) affected by varying proportions of rice, water yam, and soy bean composite flours. The phosphorus (P), Calcuim (Ca), Magnesium (Mg), and Iron (Fe) values ranged from 11.30 to 137.21 mg/100g, 15.05 to 79.95 mg/100g, 7.50 to 107.25 mg/100g, and 5.13 to 8.00 mg/100g respectively. The mineral contents increased generally as the component of soy bean increased. In the vitamin contents, only the thiamin (Vitamin B1) varied significantly (p<0.05) and ranged from 0.160 to 0.190 mg/100g. The thiamine content increased significantly with increase in the soy flour component of the mixture in the flaked samples. The incorporation of soy flour in the production of flakes is hereby recommended for improved nutritional value.

Keywords: Breakfast cereals, Mixture design,

INTRODUCTION

Breakfast cereal, also known as flakes, is a cereal-based food product made from wheat, rice, corn, or oats, and may undergo minimal processing operations, such as by drying and rolling the grain, or more substantial operations such as being cooked, and then puffed or flaked (Quatela *et al.*, 2017). Breakfast cereal was defined as dry cereal eaten at breakfast which has been processed into different forms by soaking, swelling, roasting, grinding, rolling or flaking, shredding or puffing of any cereal that is eaten as breakfast (Mbaenyi-Nwaoha and Uchendu, 2016). It was also defined to include ready-to-eat breakfast cereal (RTEBC), oats/porridge, and muesli (Williams, 2014). RTEBC is reported to have a substantial influence on the nutrient intake of children, adolescents and young adults, and are also considered as a convenient option due to their ease of preparation and popularity, which has aroused the interest of researchers in studying its nutritional quality (Wiles, 2017). Flakes have long shelf-life, low bulk density and therefore easy to store and to transport.

Multiple grains may be mixed, and nuts and/or fruits added. Breakfast cereal is generally eaten with milk or yogurt but can be eaten in a dry state. Cereal is most frequently consumed at breakfast; however, it can also be eaten as a snack or at other meals during the day. Cereal-based food products have been reported to be an age long diet for humans, and contain the macronutrients (proteins, fats, and carbohydrates), high minerals, vitamin, and other micronutrients needed for support and health maintenance (Borneo and Leon, 2011). Breakfast cereal, produced from wholegrain flour, is a good source of dietary fiber, and regular intake of wholegrain breakfast cereal may improve the function of gastrointestinal tract and reduce the risk of obesity or developing cardiovascular disease or diabetes (Wójtowicza *et al*., 2015). Fiber in our diet helps provide satiety and prevent obesity.

Nigeria's rice production has reached overwhelmingly high levels (Merem *et al*., 2017), and till date, Nigeria is the largest producer of rice in Africa. But the Nigerian local rice is still highly underutilized as industrial raw material. Water yam, is a seasonal, perishable, and underutilized crop. The expansion ratio of extruded water yam starches using a single screw extruder studied by Oke *et al*. (2013) demonstrated that water yam has great potential as a food ingredient in extruded products and can be successfully used in the preparation of snacks, pre-gelatinized flours and breakfast cereals. The use of our local rice and water yam as industrial raw materials for flakes production will increase their utilization and encourage farmers to produce more.

This study underscores the potential to develop healthier, sustainable alternatives in the cereal industry, benefiting both consumers and local economies Therefore, the objective of this study was to determine the mineral composition, and water-soluble vitamin contents of flakes prepared from local rice-water yam-soybeans composite flours.

MATERIALS AND METHODS

Polished rice of FARO 44 variety used for this study was obtained from Abakaliki rice mill in Ebonyi State, Nigeria. The tubers of *Dioscorea alata* (water yam) obtained from the farm of National Root Crop Research Institute (NRCRI), were washed with clean water to remove adhering soil and other undesirable materials. They were thereafter hand-peeled, using kitchen knives and sliced into sizes of 2 to 3cm thickness. The yam slices were dried at 60^0C in an oven. The dried yam slices was milled

The rice grains used for this study were first cooked in a pressure pot, the enlarged grains were drained in a sieve, and dried in an oven at the temperature of 60^0C. The dried grains were milled into fine flour using an attrition mill, packaged in a density polyethylene bag.

Formulation of Flour Blends and Processing of Flakes

The method of Mbaenyi-Nwaoha and Uchendu (2016) was used with some modifications. The flour blends and stepwise processes involved in the formulation of the toasted breakfast flakes are shown in Figure 1. Small quantity of water was added to the mixture of rice-water yam-soy bean flours so as to have a binding effect; sugar and salt were added to taste. The mixture was heat-treated by steaming for 10 min and then allowed to age at a temperature of 4^0C for about six (6) h. The dough was cut into very small and similar shapes in baking pans and flaked or toasted in an oven (Gallenkamp oven, size one, England) at a temperature of 120^0C for one (1) h after which the flaked/toasted breakfast cereals were allowed to cool under room temperature and packed in rigid plastic containers for analysis

Determination of Mineral and Water-soluble Contents

Mineral composition were measured according to the method described by (Padalino *et al*., 2016). Determination of Water Soluble Vitamin

The vitamin B1, B2 were determined by the methods described by (Onwuka, 2018).

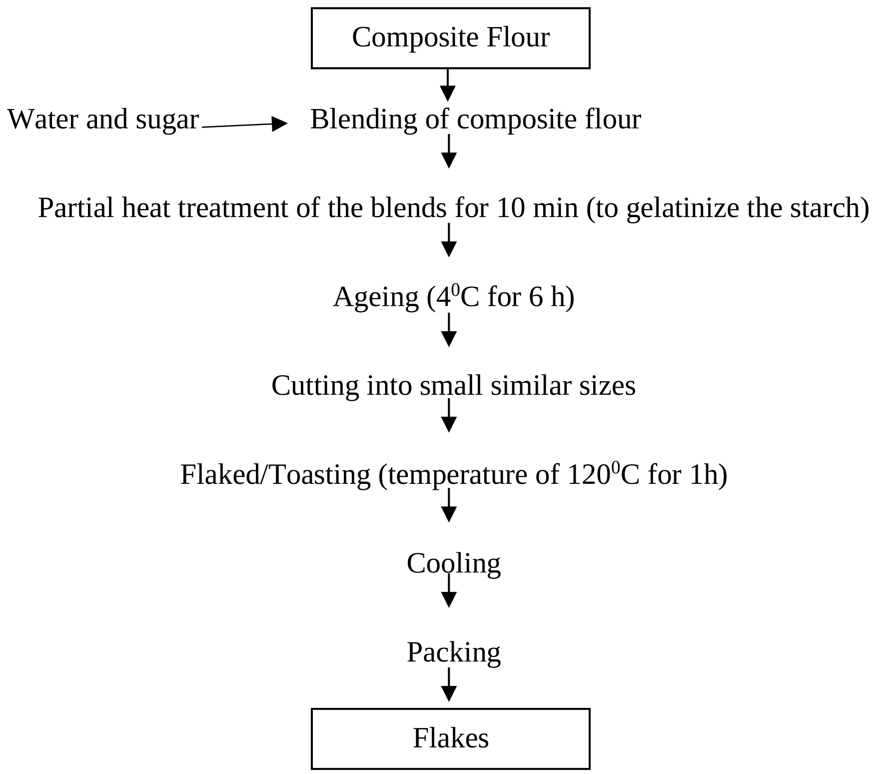

Fig 1. Flow diagram for production of flaked/toasted breakfast cereal.

Determination of thiamine

The samples were treated with dilute HCL to extract the thiamine complex which was then treated with phosphatase to liberate free thiamine. It was purified by passing through base exchange silicate alkaline column to remove interfering compounds. The column was eluted with ferricyanide to oxidise thiamine to thiochrome which was measured flourometrically.

Determination of riboflavin

Riboflavin was extracted with dilute acids and after removing the interfering substances by treatment with KMnO4, it was determined in a fluorimeter at 450 - 500 nm wavelength. The intensity of the fluorescent is proportional to the concentration. Niacin content were estimated according to the method of (Pearson, 1976), while the vitamin C content of the samples was determined by the method described by (AOAC, 2010). All analyses were performed in duplicates.

RESULTS

MINERALS (PHOSPHORUS (P), CALCUIM (Ca), MAGNESUIM (Mg), AND IRON (Fe)

Phosphorus (P)

The mineral contents of flaked samples produced in this study were significantly ($p<0.05$) affected by varying proportions of rice, water yam, and soy bean composite flours (Table 1). The major component responsible for the significant ($p<0.05$) increase in the phosphorus content of the flaked samples was the soy bean flour. The phosphorus (P) content of the flakes was also observed to increase but not significantly ($p>0.05$) with increase in the water yam flour component in the mixture. The flake sample with the highest P content was made from 50 % rice and 50 % soy bean flour, while the least P content was observed in flakes made from 100 % rice flour. This implies that soy bean flour was the major component contributing to increased mineral (P) content in the composite flour used for the production.

Calcium (Ca)

Relative high levels of Ca was observed in sample F6 which was made from 50% rice and 50% soy bean flour, while the least was observe in flakes, F4 made from50% local rice and 50% water yam. This implies that rice and water yam contain relative low Ca content when compared with soy bean Ca content

Magnesium (Mg)

Magnesium (Mg) content was observed to be highest (107.25 mg/100g) in sample F6, while the least magnesium was observed in sample F1 produced from 100% local rice flour. The amount of Mg significantly ($p<0.05$) increased with increase in the water yam flour component of the mixture, and even more increase with increase in the soy bean flour component. High level of magnesium has been observed in a variety of water yam in Sri Lanka (Senanayake *et al*., 2012).

Table 1. Mineral composition of rice-wateryam-soy beans flakes

S/n	Rice-Wyam-Soy proportions	P (mg/100g)	Ca (mg/100g)	Mg (mg/100g)	Fe (mg/100g)
F1	(100: 0: 0)	$11.30^{e}\pm0.28$	$17.50^{fg}\pm0.42$	$7.50^{f}\pm0.42$	$5.13^{d}\pm0.04$
F2	(75: 25: 0)	$20.60^{e}\pm0.85$	$15.05^{g}\pm0.78$	$14.30^{e}\pm0.28$	$5.70^{cd}\pm0.02$
F3	(75: 0: 25)	$115.23^{b}\pm6.61$	$61.50^{b}\pm1.41$	$86.70^{b}\pm3.11$	$6.39^{c}\pm0.45$
F4	(50: 50: 0)	$20.64^{e}\pm0.23$	$18.20^{fg}\pm0.42$	$17.80^{e}\pm0.42$	$5.74^{cd}\pm0.21$

F5	(50: 25: 25)	49.28^{ad}±1.87	47.40^{c}±0.85	45.60^{c}±1.13	7.80^{b}±0.14
F6	(50: 0: 50)	137.21^{a}±4.41	72.95^{a}±0.64	107.25^{a}±2.13	9.73^{a}±0.31
F7	(83.33: 8.33: 8.33)	45.65^{d}±2.33	25.85^{e}±1.20	32.00^{d}±0.71	5.69^{cd}±0.13
F8	(58.33: 33.33: 8.33)	42.57^{d}±1.09	21.50^{ef}±0.71	36.70^{d}±1.27	5.83^{cd}±0.04
F9	(58.33: 8.33: 33.33)	124.54^{b}±2.93	51.00^{c}±2.83	91.40^{b}±0.85	8.00^{b}±0.14
F10	(66.67: 16.67: 16.67)	83.05^{c}±2.33	36.35^{d}±0.92	43.03^{c}±0.75	6.00^{c}±0.13
	LSD:	12.665	6.450	6.300	0.870

Iron (Fe)

There was relative low content of Iron (Fe) in the flake samples when compared with other minerals in the samples (Table 4.16), but the values of the Fe content was significantly($p<0.05$) different from variations in the mixture components. Fe content in the flakes sample decreased with increase in the water yam component of the mixture components, and increased with increase in soy bean flour component. This might be as a result of very low levels of minerals contents observed in Nigerian varieties of *D. alata* (Okwu and Ndu, 2006).

Minerals (e.g. Ca) are essential in humans for teeth and bone formation, and normal functions of nerves and muscles. Phosphorus is an important constituent of ATP (Adenosin triphosphate) and nucleic acid, and is also an essential for acid-base balance, bone and teeth formation (Soetan *et al*, 2010). Magnesium is an important component of chlorophyll in plants, which also helps in blood vessels relaxation, improves blood flow and thus enhances nutrients transport. Excess Iron (Fe) intake can lead to liver damage (Soetan *et al*, 2010).

COMPOSITION OF WATER SOLUBLE VITAMIN OF FLAKE SAMPLES

Table 2 depicts the composition of some B-complex vitamin (thiamin, riboflavin, and niacin) and vitamin C, of flake samples produced from blends of local rice, water yam, soybean composite flours. The B vitamin generally function as co-enzymes that help the body obtain energy from food.

Thiamin (Vitamin B_1)

The thiamine contents of the flake samples ranged from 0.160 to 0.190 mg/100g, and were significantly ($p<0.05$) different. The flake samples with the highest thiamine content was prepared from the composite flour proportions (75 R: 0Y: 25S) and (66.67R: 16.67R: 16.67R), while the thiamine composition was observed in flakes made from 50% rice and 50% soy composite flours. The incorporation of soy flour might have increased significantly the thiamin content in the flake samples. The water soluble vitamin in soybeans mainly include thiamine, riboflavin, niacin, panthothenic acid and folic acid, while vitamin C content is negligible (Lokurunka, 2010). However, the values of the thiamine composition observed in this study are higher than the thiamin content (0.076 mg/100g) observed in whole wheat bread, but lower when compared with the value (0.20 mg/100g) of supplemented wheat-based bread as observed in the work of Onoja *et al* (2011). Thiamin is found in whole grains, but milling and polishing of rice have been reported to destroy 67% of Vitamin B3, 80% of Vitamin B1, 90% of Vitamin B6 and some other micro nutrients (Chaudhari *et al*., 2018). White (milled) rice was used for this study. Enrichment process adds back the nutrients lost during processing.

Vitamin B2 (Riboflavin)

The vitamin B2 contents of the noodle samples ranged from 0.026 to 0.029 mg/100g but their differences are not significantly ($p<0.05$) different. The values of riboflavin contents in this study are higher than those observed in whole wheat bread but much lower than the values observed from 'orarudi' supplemented bread (Onoja *et al*., 2014).

Vitamin B3 (Niacin)

Vitamin B3 contents of the samples ranged from 0.81 to 0.84 mg/100g. This range is lower than thiamine content of 1.3 to 2.5 mg/100g noted in milled rice. These lower values might come from losses in niacin content during processing and storage. The RDA for niacin is 16 mg/day for adult males and 14 mg/day for adult females (Berdanier and Berdanier, 2015). Keeping food products away from strong light and refrigerations reduce losses of water soluble vitamin.

Ascorbic acid (Vitamin C)

The ascorbic acid content of the noodle samples ranged from 14.43 – 17.65 mg/100g, and their differences were significantly ($p<0.05$) different. These values are about 50 % lower, when compared with the vitamin C contents noted in fresh and dried wheat and potato noodles from the study of Fen *et al*. (2017), The general low values indicate that the raw material samples (rice, water yam, and soybeans) are not rich sources of vitamin C. Soybeans contains negligible amounts of vitamin C. Furthermore, the roasting temperature from the oven might have also destroyed some vitamin C in the flour samples. Major sources of ascorbic acid are fresh fruits (e.g. citrus) and vegetables.

Table 2. Water Soluble Vitamin Composition of Flakes Samples

S/NO	R:Y:S	VIT B_1	VIT B_2	VIT B_3	VIT C
F1	(100: 0: 0)	$0.170^{ab}\pm0.00$	0.029±0.01	0.82±0.03	14.43±1.20
F2	(75: 25: 0)	$0.180^{a}\pm0.01$	0.028±0.00	0.83±0.02	16.65±2.14
F3	(75: 0: 25)	$0.190^{a}\pm0.01$	0.027±0.01	0.84±0.03	15.00±1.00
F4	(50:50: 0)	$0.160^{b}\pm0.01$	0.026±0.01	0.81±0.01	16.00±1.80
F5	(50: 25: 25)	$0.180^{a}\pm0.01$	0.029±0.02	0.83±0.04	14.95±1.04
F6	(50: 0: 50)	$0.170^{ab}\pm0.00$	0.026 ±0.01	0.82±0.02	16.50±2.10

F7	(83.33: 8.33: 8.33)	0.190[a]±0.00	0.027±0.01	0.84±0.01	15.50±1.20
F8	(58.33: 33.33: 8.33)	0.160[b]±0.01	0.026±0.01	0.81±0.02	17.50±1.00
F9	(58.33: 8.33: 33.33)	0.170[ab]±0.01	0.027±0.00	0.82±0.04	16.00±2.05
F10	(66.67: 16.67: 16.67)	0.190[a]±0.01	0.029±0.01	0.84±0.03	15.00±1.10
	LSD	0.020	NS	NS	NS

R = Rice flour, Y=water yam flour, and S=soy flour

CONCLUSIONS

Flakes can be produced from blends of local rice, water yam and soybeans. Incorporation of soybean flour in flakes production will boost the nutritional quality and increase varieties. The findings will contribute to the growing body of knowledge on the use of composite flours in addressing nutritional deficiencies, promoting food security, and encouraging the industrial utilization of indigenous crops.

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