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Development, quality evaluation and estimated contribution of composite flour snack foods to nutrient requirements of young children aged 2 to 6 years

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Snack food consumption is an avenue for the young children of the world to meet their daily nutrient requirements. In recent times, biscuits and cakes prepared from a cocktail of grain and root crops have gained much popularity due to the versatile nature and nutritional quality of their composite flours. Flour samples prepared from broken rice fractions, soybeans, and orange-fleshed sweet potato (OFSP) were used to develop appropriate formulations with wheat flour to obtain a final blend composition of 60% wheat flour, 10% rice flour, 15% OFSP and 15% soybean flour, aimed at achieving fairly high nutrient contributions in the blends with regards to protein, vitamin A, iron and zinc without necessarily sacrificing the potential aesthetic, functional and sensory characteristics of the final products. The final blend obtained was used for the preparation of cake bread and biscuit snack foods for young children aged 2 to 6 years old. The products were evaluated for their physicochemical and sensory properties as well as their possible contribution to Recommended Dietary Allowances (RDAs). Significant improvements in the protein, vitamin A, zinc and iron contents were achieved with the composite blends for both products. Consumer acceptability of the products was also appreciably high. At a moderate daily consumption rate of two 1-cm slices of the cake bread (approximately 54.0 g) or two pieces of biscuit (approximately 44.0 g), children aged 2 to 3 years will satisfy over 30, 110, 20 and 8% of their RDAs for protein, vitamin A, iron and zinc, respectively. Older children who can consume more than the amounts stipulated above could have greater percentages of their RDA satisfied. Effective promotion of the production and consumption of such products is required to help improve micronutrient consumption by young children.

Key words: Biscuit, cake bread, children, complementary snacks, micronutrient, Recommended Dietary Allowances (RDAs).

INTRODUCTION

World-wide, and especially in developing countries like Ghana, malnutrition including micronutrient deficiencies continues to be a major public health issue largely due to insufficient food intake in terms of both quality and quantity (Bhutta and Salam, 2012). Increased urbanization and globalization has also exposed many people, especially children in both urban and rural communities, to quick, convenient, cheaper and ready-to- eat processed foods and beverages that may be low in essential micronutrients (Adair and Popkin, 2005; Piernas and Popkin, 2010; Duffey et al., 2013). Deficiencies in these micronutrients are usually deleterious and almost irreversible. They include, vitamin A, iron and zinc deficiencies. The use of a variety of local food ingredients which are rich sources of micronutrients in food preparations in comparison to other interventions has proven to be a viable and sustainable approach in tackling all forms of malnutrition in addition to promoting food security in the long term (Pobee et al., 2017). Their diversification beyond the traditional food cuisines and potential uses in alternative product development such as snack food has also attracted much attention.

Recent research suggests that the consumption of snacks foods which includes biscuits, cakes and bread, soft drinks, chips and candies has increased with time as most low- to middle-income countries experience nutrition transition phenomena (Bermudez and Tucker, 2003; Thow and Hawkes, 2009). These snacks foods usually in the forms of convenience baked or fried products are mainly produced from refined wheat flour; they are self-fed and eaten between meals (Hess et al., 2016). Evidence suggests that the topmost consumers of these snack foods are young children and adolescents (Huffman et al., 2014). Wilson (1999) reported that eating between meals can contribute to total nutrient intake and ultimately help meet an individual's RDA in a day. In light of this, the composition of ingredients used in the production of these bakery foods is equally as important as the final product in attaining a nutritious and healthy snack for all age groups. In Ghana, biscuits and bread are common snacks widely consumed. They are both baked foods mainly produced from refined wheat flour and rich in carbohydrates.

Composite flour utilization in recent past from crops such as cassava, cocoyam, sweet potato, sorghum and millet for bakery products has gained prominence in many countries which traditionally import intermediate foods such as wheat flour for this purpose. Flour from these root and tuber crops have been used in the production of bread, cookies, doughnuts and noodles (Tortoe et al., 2017, Akonor et al., 2017). Their uses and benefits in the preparation of products such as biscuits and cakes have been extensively studied (Chauhan et al., 2016; Ho and Abdul Latif, 2016; Kidane et al., 2013). The choice of cereals and legumes in these blends is chiefly attributed to the complementary nature of the proteins in these cereal- legume blends that provide significant levels of essential amino acids (Amagloh et al., 2012; Lartey et al., 2000). However, in Ghana, little research results has been reported on the use of broken rice fractions in addition in some of these composite flour blends in snack food (cake bread and biscuit) preparation.

Losses in rice milling exceed 30% as broken fractions on average in Ghana due to the use of rudimentary tools and machinery in harvesting and post-harvest practices along the rice value chain (Appiah et al., 2011). These fractions are known to be a rich source of carbohydrates, fibre, B-vitamins, essential amino acids, potassium and calcium (Adu-Kwarteng et al., 2003). Broken rice flour is notably low in sodium, has a blunt taste and is gluten free hence its novelty in especially hypoallergenic snack products (Folorunso et al., 2016).

OFSP varieties released in Ghana have increased levels of β-carotene and range from yellow- to orange-coloured flesh. Considered an excellent source of pro-vitamin A carotenoids, these new varieties have the potential to address vitamin A deficiency. There is still a lack of diversity in the utilization of OFSP flour in food preparation as the majority of consumption is still limited to cooked and boiled forms in traditional meals. Successful utilization and acceptability of the orange-fleshed sweet potato by the consumer depends on creating a culturally acceptable sweet potato product, and several reports attest to this issue (Amagloh et al., 2012; Bonsi et al., 2014). Its potential impact on children's vitamin A status as well as significant improvements in vitamin A intake and serum retinol concentrations has also been well-investigated in a South African cohort (van Jaarsveld et al., 2005). OFSP is also a good source of fibre, potassium, phosphorus, vitamins E and C, iron and natural sugars, such as glucose and fructose (Lai et al., 2013), which can provide a sweet taste, colour and flavour to food enhancing its aesthetic value.

Soybeans were considered in the formulation because of their high protein content and quality amino acid profile and their content of minerals, such as calcium and iron (Plahar et al., 2003). It is for these reasons that in the current study, the concept of developing energy-dense, nutrient-rich snacks was explored using composite flour from broken rice fractions (which is an underutilized food by-product from the milling of paddy rice in Ghana), OFSP, local legumes (soybeans) and wheat flour aimed at meeting the macro and micronutrient needs of young children.

This study, therefore, specifically aimed to determine the nutritional value and physical and organoleptic properties of two snack foods (biscuits and cake bread) developed from composite flour made of OFSP, soybeans, broken rice and wheat and compared to control wheat flour. Secondly, the study also sought to

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Table 1. Blend formulations used and the expected nutritional contribution.

Blend	% Flour (w/w)				Expected nutritional contribution per 100 g			
	Wheat	Rice	OFSP	Soybean	Protein (g)	Pro-vitamin A (mg)	Zinc (mg)	Iron (mg)
Control	100	0	0	0	13.7	0.001	1.70	0.60
Composite 1	30	30	20	20	17.27	2.62	1.73	2.24
Composite 2	50	20	15	15	16.54	1.96	1.05	1.24
Composite 3	20	40	20	20	16.62	2.61	1.74	2.22
Composite 4	60	10	15	15	18.57	2.61	1.71	2.28

determine the estimated contribution of these formulated snack foods to the nutrient requirements of young children aged 2 to 6 years old. The results of this study will continue to provide opportunities for the use and support of indigenous and underutilized food crops and by-products which are readily available and culturally acceptable in healthy snack food preparations for young children and adults alike and also help achieve food and nutrition security.

MATERIALS AND METHODS

Unless otherwise stated, all ingredients and raw materials used were sourced from a bakery shop in a local market in Madina, a suburb of Accra, in the Greater Accra Region of Ghana. Orange-fleshed sweet potato (OFSP) roots (var. *Apomden santom*) used in the preparation of the sweet potato flour was supplied by a smallholder farmer in Cape Coast, Ghana. Samples of parboiled broken rice (*Oryza sativa*) fractions (var. Jasmine 85) were supplied by the Ashiaman Irrigation Project, Tema. Soybeans (*Glycine max)* were of the Salintuya variety and were obtained from the CSIR-Savanna Agricultural Research Institute, Nyankpala, Tamale.

Preparation of flours

Orange-fleshed sweet potato (OFSP) flour

The established procedure for the preparation of the orange-fleshed sweet potato (OFSP) flour for use in the formulation of the snack foods is a modification of the method developed by Plahar (2011). Selected matured fresh sweet potato roots were washed, peeled with a knife, and the peeled roots washed again in clean water. The roots were then cut into thin slices of approximately 3.0-mm thickness using a One-Touch automatic deluxe vegetable slicer (Model KC25, Daka Res. Inc., China) and soaked in 1% sodium meta-bisulphate solution for 10 min to prevent bleaching of the orange colour. The conditioned slices were then spread thinly on drying trays and dried in a mechanical dryer maintained at 60°C for ten hours. The dried slices were milled in a disc attrition mill (Hunt No. 2A Premier Mill, Hunt & Co., UK) into smooth flour. The resulting OFSP flour samples were stored sealed in polyethylene bags until use.

Full-fat soybean flour

The final procedure was a modification of the process developed by Plahar et al. (1997). Cleaned soybeans were toasted for 20 min in an electric oven maintained at 140°C. They were then dehulled by breaking in a disc attrition mill (Hunt No. 2A Premier Mill, Hunt & Co., UK) and winnowed. The dehulled grits were then milled into flour using the disc attrition mill. The flour samples were packaged and sealed in polyethylene bags and stored frozen for use.

Rice flour

A simple procedure involving sorting and milling of broken rice samples was used for the preparation of the rice flour. Sorting was performed to remove coloured pieces and chaff from the bulk. The sorted clean rice was milled in a disc attrition mill as described for the soybean samples.

Composite blend formulation

Four composite blends were formulated, and the nutritional quality evaluated theoretically to achieve a desirable nutritional composition with regards to the protein, vitamin A, zinc and iron contents. This procedure was performed using values obtained from Food Composition Tables (FAO, 2012) to obtain a product that could meet the specified RDA guidelines for young children (WHO, 2002). OFSP was chosen to provide the source of pro-vitamin A. Broken rice was used in part as a carbohydrate source and mainly as to promote its utilization in bakery products and soybeans to provide protein. Blend formulations and their expected nutritional contributions are shown in Table 1. The four formulations were screened for two snacks: Biscuits and cake bread.

Preparation of snacks

Two snacks (biscuits and cake bread) were developed from the four composite blends and control wheat flour using standard ingredient formulations as shown in Tables 1 and 2. Choice of these two snacks was influenced by the likelihood of it being adopted as similar snacks are given to pre-schoolers in Ghana. For the preparation of the cake bread, 600 g of the composite flour was sifted, and all dry ingredients including 40 g sugar, 1 g nutmeg flour, 4 g instant yeast, and 6 g table salt were weighed and mixed. Then, 300 ml evaporated milk and 2.5 ml vanilla essence were added to 300 ml warm water, poured into the flour mixture and mixed to form a firm dough. The dough was kneaded on a floured board, cut into 40 g pieces that were rounded into rolls, placed in baking pans and allowed to proof in a fermentation cabin at 35°C for 3.0 h. The rolls were baked in a preheated, locally made oven maintained at 200°C for 15 min. For the preparation of the biscuits, the composite flour was sifted, and all dry ingredients including 150 g sugar, 3.6 g baking powder, 1 g nutmeg powder, and 2.5 g table salt were weighed and mixed. Exactly 5.0 ml vanilla

Table 2. Ingredient composition of biscuits and cake bread

Ingredient	Quantity	
	Cake bread	Biscuits
Composite flour blend	600 g	600 g
Sugar	40 g	150 g
Margarine	100 g	250 g
Evaporated milk	300 ml	-
Eggs	-	164.5 g
Baking powder	-	3.6 g
Nutmeg	1 g	1 g
Yeast (Instant)	4 g	-
Table salt	6 g	2.5 g
Vanilla essence	2.5 ml	5.0 ml
Warm water*	270 - 310 ml	-

*Varied to produce right mixing consistency.

essence was added to 164.5 g eggs and whipped thoroughly. This mixture was then poured into the flour mixture and mixed manually to form a firm dough that was rolled on a floured board to a thickness of 6.0 mm, cut into 5.8 cm diameter round shapes with biscuit cutters and baked in a preheated oven at 140°C for 45 min.

Sensory evaluation

The products were evaluated for their sensorial attributes including appearance, colour, taste, crispness (for biscuits) and texture (for bread), aroma, mouth feel, after-taste and over all acceptability. A nine-point hedonic scale was used to test for the above-mentioned sensory attributes for both cake bread and biscuits. The evaluation was undertaken by a panel of twenty trained staff of the CSIR-Food Research Institute (FRI), Ghana (on two separate occasions for each snack) who had previously participated in the evaluation of snacks. The test was conducted in a facility conforming to ISO 8589. The coded samples were presented separately at room temperature to each panel member for evaluation. Panellists were provided water to refresh their palate before evaluating successive samples. This activity formed a major part of the product development process and was used in the selection of the best formulation for both snacks.

Final blend selection and quality evaluation of snack foods

Based on the above screening exercise, in addition to their expected nutritional contributions, the best blend was then selected and used for the preparation of cake bread and biscuits snack foods by the method described above, along with a wheat flour control. The samples were evaluated for consumer acceptability, nutritional quality, and physical properties and estimated contribution of the snacks to the vitamin A, iron, zinc and protein requirements of children aged 2 to 6 years.

Consumer acceptability

Mothers (66) with pre-school children (2 to 6 years) were recruited for rating the consumer acceptability of the two composite snack foods made of 60% wheat flour, 10% rice flour, 15% OFSP and 15% soybean flour and the corresponding 100% wheat flour control. These mothers were recruited from three private Nursery and Kindergarten schools in Madina, a suburb of Accra in the morning as they dropped off their kids at school. Before then, a list of candidate mothers with children aged 2 to 6 years was obtained from school heads with permission and prior notice provided to the mothers. Subsequently, a letter was written to inform the mothers of the purpose of the study through the heads of these schools. From each school, twenty-two mothers were randomly selected from the list to participate after informed consent was signed. Mothers were used rather than the targeted pre-school children because mothers' and children's food preferences are said to be significantly but moderately related, and their acceptance of food can influence their children's intake (Tomlins et al., 2007). Each mother tasted one piece of biscuit (approximate 22 g) and one slice of cake bread (approximately 27 g) of both composite and control wheat samples presented in random order and coded with three digit random numbers. Mothers assessed the products separately based on colour, taste, appearance, flavour and overall acceptability. Evaluation was performed using a nine-point hedonic scale with 1 representing "dislike very much" and 9 representing "like very much". Mothers were also made to sign a consent form before the study was carried out.

Chemical analysis

Moisture (AOAC 925.10), protein (AOAC 984.13), fat (AOAC 920.39C) and ash (AOAC 923.03) were determined by the AOAC (2005) standard methods while carbohydrates were calculated by difference and energy values were obtained using the Atwater factors 3.47, 8.37 and 4.00 for protein, fat and carbohydrates, respectively (Eyeson and Ankrah, 1975). Iron and zinc were determined by the atomic absorption spectrophotometric methods with a Perkin Elmer atomic absorption spectrophotometer No.3030 (AACC, 2000). The pro-vitamin A content of the products was determined following the HPLC method described by Rodriguez-Amaya and Kimura (2004), and the vitamin A/retinol equivalent was calculated subsequently as described by WHO/FAO Joint Expert Consultation (2002).

Colour measurements

The colour of cake bread and biscuit samples was measured using the L*, a* and b* colour space (CIE LAB space) with Colorimeter

Table 3. Mean sensory scores for cake bread snack foods from composite flours and control[1].

Sensory characteristic	Wheat/rice/soy/OFSP blends				
	Composite 1	Composite 2	Composite 3	Composite 4	Control
Appearance	4.85 ± 2.30[d]	6.25 ±1.70[c]	5.30± 2.00[d]	7.35± 1.30[b]	8.60 ± 0.60[a]
Colour	4.55 ± 2.50[d]	6.40 ±1.90[c]	5.30 ± 2.20[d]	7.30 ± 1.50[b]	8.55 ± 0.60[a]
Taste	4.90 ±2.40[b]	5.65 ± 2.00[b]	5.10 ±2.00[b]	7.60 ±1.30[a]	8.05 ± 1.40[a]
Aroma	5.60 ± 2.00[b]	6.15 ± 1.80[b]	5.75 ± 1.90[b]	7.25 ±1.30[a]	8.00 ± 1.10[a]
Texture	5.55 ±2.10[c]	6.15 ± 2.00[c]	6.00 ±2.30[c]	7.10 ± 1.20[b]	8.40 ± 0.80[a]
Mouth-feel	5.05 ±2.00[c]	5.95 ± 1.90[c]	5.50 ±1.80[c]	7.00 ±1.60[b]	8.30 ± 1.20[a]
After-taste	4.40 ±2.20[d]	5.75± 2.10[c]	5.10± 2.00[c]	6.80 ± 1.60[b]	8.15 ± 1.20[a]
Overall acceptability	4.80± 2.10[b]	5.85± 1.90[b]	5.15± 2.10[b]	7.60± 1.40[a]	8.30 ± 0.90[a]

Values show the mean ±SD (n=25 adult staff of FRI). Means in a row with different superscript letter are significantly different (P<0.05)
[1]Interpretation of scores: 1 = dislike extremely; 2 = dislike very much; 3 = dislike moderately; 4 = dislike slightly; 5 = indifferent; 6 = like slightly; 7 = like moderately; 8 = like very much; 9 = like extremely.

CR-200 (Minolta, Model CR310, Minolta Camera Company Ltd., Osaka, Japan). The measurements were taken for both the top and bottom of each sample. The measuring head of the meter was carefully placed on three different locations on the sample and the meter reading taken. Measurements were determined in triplicate, and the mean and standard deviations determined. The L^* value indicates lightness, where $L^* = 0$ is completely black and $L^* = 100$ is completely white. The a^* values represent red to green with positive a^* and negative a^* depicting red and green, respectively. The b^* values on the other hand represent yellow to blue, with positive b^* representing yellow and negative b^* representing blue. The meter was calibrated with a white tile (L^*=97.51, a^*= +0.29, and b^*=+1.88). ΔE values were calculated to indicate the extent of deviation of colour in the samples from the standard tile colour used. ΔE is calculated as the square root of the sum of the squared deviations of L^*, a^* and b^* values (Oduro-Yeboah et al., 2010):

$$\Delta E = \sqrt{[\Delta L^2 + \Delta a^2 + \Delta b^2]}$$

Water activity measurement

The water activity of ground samples of biscuit and cake bread was measured at 25°C using a hygrometer (Rotonic Hygrolab®, Rotronic AG, Grindelstrasse 6, 8303 Basserrsdorf, Schweiz). All parameters were analysed in triplicate on an as-is basis.

Statistical analysis

Data were analysed using the Statistical Package for Sciences (SPSS, version 21.0) statistical software to generate means and standard deviations of triplicate determinations. Statistical parameters were estimated using analysis of variance (ANOVA). Differences between means were evaluated by the Duncan's new multiple range test, and significance was accepted at P<0.05

RESULTS AND DISCUSSION

Sensory evaluation for selection of final blend

Results of sensory evaluation of cake bread and biscuits samples prepared with the different levels of composite flour as compared to the control are shown in Tables 3 and 4, respectively. Subsequently, selection of the final blend was based on the highest mean sensory scores for the cake bread and biscuit samples produced with the four composite blends. Colour and appearance, like any other sensory attribute, play a major role in determining consumer acceptance of food products. Particularly in bakery goods, colour and appearance constitute one major sensory characteristic that determines consumer choice in Ghana. Colour and appearance therefore are important sensory properties considered in all food product development efforts. For these sensory attributes, there were significant differences (P<0.05) in the composite cake bread samples and the control. The low rating of colour and appearance compared to the control can be attributed to the darker colour and brownish appearance of the cake bread across composite flours as the substitution for wheat flour with soybeans, OFSP and rice flour increased. However Composite 4 was rated "liked moderately" for both attributes with a mean score of 7.35 and 7.30 for appearance and colour respectively, which were significantly higher than the scores for the other composite flours. Browning in bread could be directly related to the increase in fibre content (Ndife et al., 2011) as well as caramelization and maillard reactions as the protein contributed by the soybean flour must have reacted with the added sugars and the natural sugars in the OFSP during the baking process (Dhingra and Jood, 2002). A decrease in colour score of composite flour baked products as substitution increased has been noticed by Sharma and Chauhan (2000).

Aroma and taste are two key sensory attributes which affect the perception of food to be consumed. For aroma and taste, Composite 4 cake bread was rated the same in the degree of likeness as the control ("like very much"). Statistically, there was no significant difference (P>0.05) between Composite 4 sample and the control samples for

Table 4. Mean sensory scores for biscuit snack foods from composite flours and control[1].

Sensory characteristic	Wheat/rice/soy/OFSP blends				
	Composite 1	Composite 2	Composite 3	Composite 4	Control
Appearance	6.75 ± 1.50^{b}	7.25 ± 1.70^{ab}	6.05 ± 2.00^{b}	7.45 ± 1.10^{ab}	7.95 ± 1.10^{a}
Colour	6.45 ± 1.60^{b}	7.05 ± 1.90^{a}	6.00 ± 1.90^{b}	7.58 ± 0.80^{a}	8.25 ± 0.70^{a}
Taste	5.85 ± 1.70^{d}	7.25 ± 1.50^{b}	6.40 ± 1.70^{c}	7.60 ± 0.80^{b}	8.35 ± 0.80^{a}
Aroma	6.50 ± 1.60^{c}	7.40 ± 1.30^{b}	6.50 ± 1.60^{c}	7.45 ± 0.90^{b}	8.20 ± 0.80^{a}
Crispness	5.65 ± 1.80^{d}	6.75 ± 1.50^{c}	5.95 ± 1.80^{d}	7.55 ± 1.30^{b}	8.05 ± 0.10^{a}
Mouth-feel	6.35 ± 1.60^{c}	7.10 ± 1.30^{b}	6.20 ± 1.60^{c}	7.45 ± 0.90^{b}	8.50 ± 0.60^{a}
After-taste	6.45 ± 1.50^{c}	7.00 ± 1.40^{b}	6.10 ± 2.00^{c}	7.45 ± 0.90^{b}	8.45 ± 0.50^{a}
Overall acceptability	6.05 ± 1.70^{c}	7.25 ± 1.40^{b}	6.15 ± 1.70^{c}	7.55 ± 0.90^{b}	8.50± 0.60^{a}

Values show the mean ±SD (n = 25 adult staff of FRI). Means in a row with different superscript letter(s) are significantly different (P<0.05)
[1]Interpretation of scores: 1 = dislike extremely; 2 = dislike very much; 3 = dislike moderately; 4 = dislike slightly; 5 = indifferent; 6 = like slightly; 7 = like moderately; 8 = like very much; 9 = like extremely.

aroma and taste. The other three composite flours produced cake bread samples with similar but significantly reduced aroma and taste scores. The not significant difference (P>0.05) between Composite 4 and the control can be attributed to the relatively lower soy, rice and OFSP flour substitution in Composite 4 blend. The presence of more rice and OFSP as well as soybean flours could have accounted for the lower ratings of Composites 1, 2 and 3. In addition to this some of the panellist expressed a limiting sensory attribute of a beany aroma and "root crop" after-taste in these samples. Several studies have reported that higher substitution of wheat flour with soybeans and OFSP in bread and biscuits making was associated with a beany flavour, "root" aroma and after taste (Sabanis and Tzia, 2009; Tortoe et al., 2017).

The scores for texture and mouth feel which depicts softness and chewiness of the composite cake bread samples decreased with OFSP, soybean and rice flour substitution as shown by the ratings describing them in Table 3 compared to the control. However, Composite 4 produced cake bread with ratings of "like moderately". Cake bread containing rice flour between 30 and 40% and OFSP and soybean flour of 20% each representing Composites 1 and 3 had the lowest sensory rating relative to Composite 4 and the control. The contribution of additional fibre ostensibly from rice, OFSP and soybean in the composite blends might have resulted in the hard texture of the cake bread relative to the control (Sabanis and Tzia, 2009). Substitution of wheat flour with non-wheat flour in bakery products results in the retention of less gas hence producing a dense texture that is undesirable to the consumer.

Over all acceptability scores generally revealed that Composites 2 and 4 which had between 10 to 20% wheat flour substituted for rice flour and 15% wheat flour substituted for OFSP or soybean flours were "liked slightly" and "liked very much" respectively. In totality, Composite 4 produced cake bread samples were rated highest amongst all attributes and was not significantly (P>0.05) different from the control wheat sample.

A similar trend to the cake bread was observed in the sensory ratings of biscuits produced from the four composite flours (Table 4). Sensory attributes for biscuits prepared with Composite 1 were rated between 'like slightly' to 'like moderately', whereas those for Composite 3 were all rated 'like slightly'. Biscuit products from Composite 2 had all the sensory attributes scored 'like moderately' with scores for Composite 4 biscuits indicating between 'like moderately' and 'like very much'. Taste, colour, crispness and overall acceptability for the Composite 4 biscuits had scores indicating 'like very much'.

From the above sensory scores for both the cake bread and biscuits produced from the four composite flours and the control, it was quite apparent that Composite 2 and Composite 4 were the best formulations and would produce acceptable products in addition to their nutritional attributes. From the theoretical values shown in Table 1, however, Composite 4 was expected to have higher content of protein, vitamin A, zinc and iron than Composite 2. In addition to its higher mean scores for the sensory attributes, Composite 4, consisting of 60% wheat flour, 10% rice flour, 15% OFSP and 15% soybean flour, was considered the best blend for use in the production of the snack foods for the desired nutritional and sensory attributes.

Consumer acceptability

The mean scores for consumer acceptability of the snack foods are shown in Table 5. For all the sensory attributes, mean scores for the cake bread ranged between 8.0 and

Table 5. Consumer acceptability of composite snack foods compared with the control.

Component	Cake bread		Biscuit	
	Control wheat flour	Composite flour	Control wheat flour	Composite flour
Appearance	8.20±0.66[a]	7.82±0.63[a]	7.80±0.68[a]	7.50±0.66[a]
Colour	8.41±0.78[a]	7.50±0.64[b]	8.61±0.58[a]	7.91±0.80[a]
Taste (sweetness)	8.59±0.63[a]	7.61±0.60[b]	8.21±0.83[a]	7.61±0.76[b]
Flavour	8.00±0.63[a]	7.85±0.61[a]	8.11±0.59[a]	7.71±0.70[a]
Overall Acceptability	8.41±0.70[a]	7.89±0.59[a]	8.00±0.68[a]	7.89±0.81[a]

Values show the mean ±SD (n = 66 mothers with pre-school children 2 to 6 years). For each snack food, figures in a row with different superscript letter are significantly different (P<0.05). [1]Interpretation of scores: 1 = dislike extremely; 2 = dislike very much; 3 = dislike moderately; 4 = dislike slightly; 5 = indifferent; 6 = like slightly; 7 = like moderately; 8 = like very much; 9 = like extremely.

8.6 for the control (indicating 'like very much' to 'like extremely') and between 7.5 and 7.9 for the composite flour cake bread (indicating 'like moderately' to 'like very much') on the 9-point hedonic scale. Except for colour and taste, all other sensory attributes had the same degree of likeness (P>0.05) for both the composite flour cake bread and the control, and this pattern was also true for the overall acceptability mean scores. The slight but significant differences observed in the colour and taste of the composite flour cake bread and the control could be attributed mainly to the orange colour and sweetness of the OFSP in the composite flour (Lai et al., 2013) and also the browning reaction during baking. This variation, albeit significant, had no effect on the degree of liking, as the mean scores for both products are interpreted as 'like very much' for colour and taste. Consequently, both control and composite cake bread samples showed no significant difference in overall acceptability. Similar results were observed for composite breads prepared with 40% OFSP compared with 100% wheat bread (Rangel et al., 2011).

Acceptability scores for biscuits also ranged from 7.8 to 8.6 for the control wheat biscuits and from 7.5 to 7.9 for biscuits made from the composite flour (Table 5). Here, except for taste, all other sensory attributes of the biscuits made with composite flour were not significantly different (P>0.05) from the control, including the overall acceptability scores. Again, this variation in taste, though significant, did not affect the degree of liking ('like very much') on the 9-point hedonic scale. This finding is an affirmation that snack foods prepared from composite flour blends of 60% wheat flour, 10% rice flour, 15% OFSP and 15% soybean flour are acceptable and can lead to enhanced utilization of local raw materials in composite food preparations. Similar scores of acceptability of biscuits made with approximately 10% OFSP and wheat was observed in other studies (Laelago et al., 2015).

These results are in concordance with the results from the semi-trained panellist sensory scores, which is a good indication that the cake bread and biscuit products are likely to be accepted by the target group leading to enhanced consumption.

Product quality evaluation

Proximate composition and water activity (a_W)

The final blend composition of 60% wheat flour, 10% rice flour, 15% OFSP and 15% soybean flour was used to prepare cake bread and biscuit samples and the quality evaluated.

The results obtained for the chemical and physical properties investigated are shown in Table 6. Generally, the values for ash, fat and protein were lowest in the control wheat flour produced caked bread and biscuits samples and higher in the composite flour produced samples albeit not significant (P>0.05) with fat content of the cake bread. These differences could be attributed to the composite flour blend components. Ash content of the composite blend increased due to the significantly higher mineral content of all the non-wheat flours. The reverse however was recorded for the carbohydrate and energy values for both products. These results are in agreement with those obtained by Ndife et al. (2011). The relatively low energy and carbohydrate values in the composite flour products may be attributed to the lower levels of wheat flour used relative to the control. Also the lower energy values can be attributed to the apparently higher fibre (data not shown) and protein content in the composite flour. Dietary fibre forms a significant fraction of the bran of whole grains and their health promoting benefits have been researched extensively (Malunga et al., 2017). Using composite flour made from grain cereals and root and tubers in bread and biscuit preparation increases the fibre content which lowers the carbohydrate value of the product. This finding was reported by Serrem et al. (2011) who obtained similar results. The energy values obtained from the composite flour products conformed to the FAO/WHO (1994) recommended minimum energy

Table 6. Proximate composition, vitamin A, iron, zinc, and water activity (A_w) of formulated snack foods prepared from wheat, rice, soybean and OFSP composite flours.

Component	Cake bread		Biscuit	
	Control wheat flour	Composite flour	Control wheat flour	Composite flour
Moisture (g/100 g)	29.20±0.04^{b}	32.60±0.01^{a}	2.80±0.08^{d}	3.40±0.07^{c}
Protein (g/100 g)	7.89±0.07^{c}	8.76±0.07^{b}	6.49±0.04^{d}	9.48±0.02^{a}
Fat (g/100 g)	10.67±0.01^{c}	10.69±0.11^{c}	24.22±0.16^{b}	25.71±0.23^{a}
Ash (g/100 g)	1.30±0.01^{c}	1.83±0.02^{b}	1.11±0.01^{d}	2.11±0.01^{a}
Carbohydrates (g/100 g)	50.97±0.03^{c}	46.10±0.07^{d}	65.36±0.13^{a}	59.30±0.20^{b}
Energy (Kal/100 g)	320.57±0.16^{b}	304.35±0.69^{c}	486.68±1.12^{a}	485.29±1.42^{a}
Vitamin A (mg RE/100 g)	0.037±0.003^{d}	0.624±0.007^{b}	0.127±0.043^{c}	0.810±0.013^{a}
Iron (mg/100 g)	1.92±0.12^{d}	2.86±0.27^{b}	2.53±0.16^{c}	4.00±0.18^{a}
Zinc (mg/100 g)	0.51±0.14^{c}	0.69±0.35^{a}	0.52±0.01^{c}	0.56±0.01^{b}
Water activity (A_w)	0.89±0.001^{a}	0.89±0.002^{a}	0.55±0.020^{b}	0.44±0.007^{c}

[1]Values are averages of duplicate readings (Mean ± SD). Means with different superscript letter in a row are significantly different (P< 0.05).

content of 400 Kcals/100 g.

The moisture content of the samples ranged between 2.8% for control wheat flour biscuits to 32.6% for the composite flour cake bread (Table 6). Generally, the biscuit samples contained very low moisture (2.8 and 3.4%, respectively, for the control wheat flour and composite flour). The higher moisture content in the composite flour products relative to the control may be attributed to the blend composition of the composite flours. Soluble protein contained in soy flour contributes to a greater moisture holding capacity (Sabanis and Tzia, 2009). In addition, the high fibre content in the composite blend caused retention of moisture. High fibre content in foods is known to be associated with moisture retention (Maneju et al., 2011). Although the moisture content of the composite flour biscuit was greater than for the control, the corresponding water activity values did not follow the same trend. The presence of rice, soy and OFSP flours in the composite flour blend bound some of the available water to reduce the water activity. Water activity values of 0.89 as obtained for the cake bread samples in the present study are likely to encourage proliferation of microorganisms, including many types of yeast, such as Candida*, Torulopsis, and Hansenula* and *Micrococcus* (Fennema, 1985), if the product is kept for a long period of time on the shelf. Fortunately, such products are typically consumed within a few days after baking. The biscuit samples, on the other hand, had such low water activity values that they will not encourage any microbial proliferation.

Vitamin A, iron and zinc content

The composite flour produced cake bread and biscuit samples resulted in significantly higher (p<0.05) contents of vitamin A than their corresponding wheat flour control samples (Table 6). Similar results were recorded for iron and zinc contents. According to Nzamwita et al. (2017) wheat flour is a poor source of vitamin A. Several studies involving the use of OFSP flour in product formulations have reported significant pro-vitamin A carotenoid concentrations in the final product as well as higher serum vitamin A status in biological samples after consumption (van Jaarsverd et al., 2005; Low et al., 2007; Bonsi et al., 2014; Pobee et al., 2017). Deficiencies of essential micronutrients especially those of public health concern are deleterious and their cost to productivity is unquestionable. These findings suggest that food ingredients such as OFSP when used as a strategy to combat micronutrient malnutrition will not only be successful but also sustainable. According to the FAO (2009), vitamin A, iron and zinc are responsible for most of the micronutrient deficiency problems in Ghana. In a study conducted in Northern Ghana, Simler et al. (2005) found that 75% of children aged between two and five years suffer from sub-clinical vitamin A deficiency, and 35% suffer from severe vitamin A deficiency. Under the prevailing circumstances, the formulated snack foods from the present study will contribute significantly to the search for a sustainable means to help solve these micronutrient deficiency problems. Vitamin A is essential in the health of the cornea, gastrointestinal tract, skin, urinary tract and lungs. The vitamin A content in the composite flour snack foods meets more than enough for all age groups.

Iron content also increased significantly by 48.96 and 58.0% in the composite flour samples respectively for cake bread and biscuit, while increases of 35.3 and 7.7% were recorded for zinc. Both nutrients are essential and are important in haematopoiesis and the prevention of

Table 7. Colour values of formulated snack foods prepared from wheat, rice, soybean and OFSP composite flours.

Component	Cake bread		Biscuit	
	Control wheat flour	Composite flour	Control wheat flour	Composite flour
Top colour				
L	58.02±0.89^{c}	49.94±0.34^{d}	67.39±1.65^{a}	60.65±1.68^{b}
a	+9.36±0.26^{a}	+8.91±0.21^{a}	+0.53±0.20^{c}	+1.62±0.09^{b}
b	+20.99±1.09^{b}	+11.32±0.38^{c}	+23.79±1.44^{a}	+24.18±1.25^{a}
ΔE	44.80^{b}	49.26^{a}	37.25^{d}	43.10^{c}
Bottom colour				
L	75.87±0.61^{a}	63.65±0.94^{c}	70.58±0.08^{b}	53.40±1.53^{d}
a	+0.23±0.04^{d}	+1.72±0.44^{b}	+0.75±0.05^{c}	+4.40±0.13^{a}
b	+24.77±0.72^{b}	+28.27±0.34^{a}	+25.35±1.72^{b}	+18.65±1.64^{c}
ΔE	31.50^{d}	42.95^{b}	35.73^{c}	47.37^{a}

[1]Values are averages of duplicate readings (Mean ± SD). Means with different superscript letter in a row are significantly different (P< 0.05).

anaemia especially in children below 5 years and women in general. Zinc is especially important for the prevention of infections and to support the immune system as well as in growth, cognitive and motor development (Busie et al., 2017; Nzamwita et al., 2017).

Colour

Bakery products are supposed to have a peculiar colour gamut for the topside and the bottom side that should meet consumer expectations. In the present study, the colour of the snack foods produced from the composite flour was measured at both the topside and the bottom side and compared with that of the standard control samples to determine the extent to which consumer expectations could be satisfied. The results indicated that control bread and biscuit samples were slightly but significantly lighter in colour at the topside, as indicated by the greater L* values, than the composite flour products (Table 7). The a* values for the topside of the control flour biscuit samples also showed less intense red colour than the composite flour samples. The composite flour cake bread samples, however, recorded slightly but significantly deeper topside red colour than the control. Several studies have reported a lower L value for bread produced with composite flours including soy, cowpea or fenugreek flour (Hooda and Jood, 2005; Sabanis and Tzia, 2009). Positive b* values obtained for the topside of the cake bread and biscuit samples indicated degree of yellowing. Whereas the same intensity of yellow was obtained for control and composite biscuit samples, the cake bread samples showed a deeper yellow in the control samples than the composite flour products. OFSP flour has a distinctive yellow to orange colour and this has an influence on their products determining the degree of consumer acceptance. Apart from being antioxidants, OFSP are rich sources of pro-vitamin A carotenoids, a precursor of vitamin A. This vitamin is essentially important in the prevention of night blindness and certain atherosclerosis conditions. The ΔE values obtained clearly show a wider deviation in colour of the composite flour products from the standard tile colour than the control flour samples.

Similar to the topside colour values, the bottom side colour of the control samples were also lighter in colour (greater L* values) than the composite flour products for both the cake bread and biscuit samples. Additionally, the degree of redness in both products were different for composite and control with the composite giving a more red colour than the control as indicated by the a* values (Table 7). As observed with the topside colour of the products, there were significant differences in the deviations from the standard tile colour between the control and composite flour for both cake bread and biscuits with the composite flour products showing greater deviations from the standard white tile. The differences obtained in the instrumental measurements of L*, a*, and b* values confirmed the slight differences in the sensory scores for colour shown in Tables 3 and 4, where the samples were rated between 'like moderately' and 'like very much' and close to the wheat flour controls.

Estimated contribution of composite flour snack foods to RDA of pre-school children aged 2 to 6 years

The results for the contribution of the two snack foods to the RDA of children aged 2 to 6 years is shown in Table 8. These contributions were based on an assumed minimum daily serving size of two 1-cm slices of the cake

Table 8. Estimated contribution (%) of composite flour snack foods to RDA for protein, vitamin A, iron and zinc for children between two and six years old.

Nutrient		Age group (Years)			
		2 -3		4-6	
RDA per day[1]	Protein (g)	13.0		19.0	
	Vitamin A (µg)	300		400	
	Iron (mg)	7.0		10.0	
	Zinc (mg)	3.0		5.0	
		Bread	**Biscuit**	**Bread**	**Biscuit**
Contribution from snack food per day[2]	Protein (g)	4.73	4.17	7.10	6.26
	Vitamin A (µg RE)	337.42	356.98	506.14	535.48
	Iron (mg)	1.54	1.76	2.32	2.64
	Zinc (mg)	0.37	0.25	0.56	0.37
% of RDA	Protein	36.4	32.1	37.4	32.9
	Vitamin A	112.5	119.0	126.5	133.9
	Iron	22.0	25.1	23.2	26.4
	Zinc	12.3	8.3	11.2	7.4

RDA, Recommended Dietary Allowance; [1]Source: Food and Nutrition Board (2003). [2]Based on an assumed serving size of two 1-cm slices cake bread (approximately 54.0 g wb) or two pieces of biscuit (approximately 44.0 g wb) for two- to three-year-olds, and three 1-cm slices cake bread (approx. 81.0 g wb) or 3 pieces of biscuit (approximately 66.0 g wb) for four- to six-year-olds.

bread (approximately 54.0 g) or two pieces of the biscuit (approximately 44.0 g) for the two- to three-year-old age group, and three 1-cm slices of bread (approximately 81.0 g) or 3 pieces of biscuit (approximately 66.0 g) for the four- to six-year-old age group. This assumed quantity of consumption is justified from informal information obtained from interactions with mothers used in the consumer acceptability studies because there was no publication on quantity of consumption for these age brackets. At this rate of consumption, children aged 2 to 3 years old will satisfy approximately 36, 112, 22 and 12% of their RDA for protein, vitamin A, iron and zinc, respectively, from the cake bread and 32, 119, 25 and 8% of their RDA for protein, vitamin A, iron and zinc, respectively, from the biscuits (Table 8). Children above this age group (that is, 4 to 6 years old) will satisfy more than the amounts stipulated above. From the values obtained, the products could satisfy more than the RDA for vitamin A as well as significant proportions of protein and iron requirements at the assumed consumption levels.

Conclusions

It is economic and nutritionally satisfactory for the consumer to have alternative products on the market that best suits their needs. From this study, the use of 60% wheat flour, 10% rice flour, 15% OFSP and 15% soybean flour in composite flour for cake bread and biscuits was found to be nutritionally superior to refined wheat flour cake bread and biscuits using the same quantity of bakery ingredients. Substitution of wheat flour with broken rice fractions, OFSP and soybean flours resulted in significant increases in pro-vitamin A carotenoid, protein and zinc contents and met the recommended minimum energy requirements of about 400 Kcal/100 g of food. Consumer acceptability of the products was also quite high. Consumption of the baked products will also contribute significantly to the RDA of young children especially for vitamin A, iron and zinc on a daily basis. Composite blends as was used in the present study could serve as an alternative source of less expensive yet nutritious flours for the preparation of cake breads and biscuits. There is however the need to ascertain the bioavailability of these nutrients in the products taken into consideration the phytate content of whole grain cereals and root and tuber crops.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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