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DETERMINATION OF THE MICRONUTRIENT COMPOSITION OF COMPLEMENTARY FOOD PREPARED FROM ORANGE FLESHED SWEET POTATO AND GERMINATED *MORINGA* SEED FLOUR BLENDS

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ABSTRACT
The micronutrient composition of blends prepared from orange fleshed sweet potato and moringa seed flours were evaluated. Orange fleshed sweet potato and moringa seed flours were prepared and blended at different ratios (100:0, 95:5, 90:10, 85:15 and 80:20). The water-soluble vitamins and minerals content of the samples were determined and compared to a commercial infant food (Nestlé CERELAC). Result showed that the samples contained calcium, magnesium, phosphorus, iron and zinc in the range; 248.08 - 259.10 mg/100g, 40.08 - 44.10 mg/100g, 51.90 - 59.00 mg/100g, 5.33 -10.25 mg/100g, 4.09 - 6.00 mg/100g, respectively. The samples would contribute approximately 27.00 - 51.25% and 24.54 – 120 % of the Recommended Daily Allowance for iron and zinc. The samples compared favourably with Nestlé CERELAC and could therefore be included in the diets of infant as a cheaper source of micronutrients or a healthier substitute for local preparations.

Key Words: Micronutrient, Orange Fleshed Sweet Potato, Moringa seed, Complementary feeding

INTRODUCTION

Child feeding practices determine the nutritional status of children including their vulnerability to malnutrition and illnesses (Anigo *et al.,* 2010; Solomon, 2005). Nutritionally deficient preparations that do not satisfy the minimum requirement for proper growth are usually made for infants in Nigeria (Agbon *et al.,* 2009). This is due to the fact that commercial infant formulas that are enriched with these micronutrients are unaffordable by most families and thus, they result in giving their children foods that are inadequate in nutrients (Solomon, 2005). Among the essential nutrients required for the optimum growth and wellbeing of children are micronutrients. According to Ekwuagwu *et al.,* (2008), micronutrients of public health significance include zinc, iron, iodine and vitamins A, C, D, E, B_1, B_2, and folate. Deficiency in these micronutrients increases the risk of death from common diseases and infections such as pneumonia, gastroenteritis and measles (Ekwuagwu *et al.,* 2008).

Orange Fleshed Sweet Potato (OFSP) is a bio-fortified crop developed through natural hybridization or genetic bio-fortifications (Tang, 2013). It is richly dense in beta carotene (300-1300 µg) and contains important micronutrients such as thiamine (0.08 mg), riboflavin (0.06 mg), niacin (0.56 mg), pyridoxine (0.21 mg), iron (0.32-0.88 mg), zinc (0.18-0.57 mg) vitamin C (22.7 mg), and Vitamin E (0.26 mg) (Low *et al.,* 2009). It has been shown that nutritionally improved foods can be developed using OFSP as the main or supplementing ingredient (Mamo *et al.,* 2014; Sinha *et al.,* 2015; Desalegn *et al.,* 2015). Despite the potential benefits of OFSP, Nigeria is one of the states in sub-sahara Africa where the utilization is very low (Fetuga *et al.,* 2013).

Moringa oleifera is an under-utilized plant attracting the attention of researchers over the years. This may be attributed to its versatility in terms of medicinal, nutritional and culinary uses (Gadzirayi *et al.*, 2013; Omotesho *et al.,* 2013; Kawo *et al.,* 2009). It is an oil rich plant food (Mbah *et al.,* 2012) and amazingly contains all the essential amino acids typical of an animal source. The seed has been reported to contain an ample of important minerals, essential amino acids, fatty acids and phyto-chemicals in addition to its adequate proximate composition (Ijarotimi *et al.*, 2013). It is rich in protein (18.63%), contains aluminium (144 ppm), calcium (602 ppm), potassium (732 ppm), phosphorus (0.619 mg/kg), sodium (86.2 ppm), manganese (17.5 ppm) and other elements (Kawo *et al.,* 2009). *Moringa* seed had been known to combat malnutrition in infant and nursing mothers (Abiodun *et al.,* 2012). Kawo *et al.,* (2009) showed that the seeds are sufficient to supply the daily nutrient requirements for children and lactating mothers.

It is imperative to seek for solutions to current challenges associated with child nutrition in Nigeria. The aim of this study was therefore to assess the suitability of OFSP and *moringa* seed flours in the development of complementary food in terms of their micronutrient composition.

MATERIALS AND METHOD

Orange Fleshed Sweet Potato (OFSP) tubers were obtained from Agbamu area in Kwara State while *Moringa oleifera* seeds were collected from Tanke Bubu area, Ilorin, Kwara State, Nigeria.

The OFSP tubers were sorted, washed, peeled and sliced into 2.5-5mm thickness. The slices were then blanched (80 ^{0}C for 2 min), subjected to cabinet drying at 60 ^{0}C for about 4 hours, milled into flour, sieved and packaged till further use. *Moringa oleifera* seeds were carefully sorted, rinsed and soaked in distilled water (1:3 w/v) for 24 hours (Alabi *et al.*, 2015). The drained seeds were allowed to germinate for 4 days (Ijarotimi *et al.*, 2013) after which they were dehulled and shade dried (28±2 °C) for 4 days. The properly dried seeds were hammer milled into flour, sieved and packaged till further use.

Formulation: The composite flours were formulated from OFSP and germinated *moringa* seed flour in the proportions (100: 0; 95:5; 90:10; 85:15 and 80: 20).

Determination of Mineral Content: The calcium, magnesium, phosphorus, iron and zinc contents of the samples were determined using the dry ashing method (AOAC 2005).

Water Soluble Vitamins: Thiamine, riboflavin, niacin, biotin, pyridoxine, folate and vitamin C were determined using standard analytical methods (AOAC, 1995). Biotin was determined using hydrolysis method.

Statistical Analysis: Data obtained were subjected to analysis of variance (ANOVA) and differences among means were separated by Duncan multiple range test at 5% probability level. All computations were made by statistical software SPSS (version 16).

RESULTS AND DISCUSSION

Mineral composition: The mineral composition of tested samples is presented in Table 1. The calcium contents ranged from 248.08 - 259.10 mg/100g, and significantly higher than that of the control (108.14 mg/100g). The sample containing 95/5 OFSP and germinated moringa seed flour had the highest value while 100% OFSP had the lowest. The aforementioned range of values is higher than that reported by Abiodun *et al.* (2012), for moringa (203.85 mg/kg) and moringa cake flour (249.85 mg/kg). Magnesium (Mg) content of the samples ranged from 40.08 - 44.10mg/100g, which was higher than 39.18mg/100g of the control. The 100% OFSP had the highest value (44.10mg/100g). Magnesium is an essential nutrient for the appropriate utilization of vitamin B and E and functions with other minerals such as calcium , sodium and potassium in maintaining osmotic balance (Nafiu *et al.*, 2011). The samples with *moringa* seed inclusion had higher concentration of phosphorus (51.90mg/100g – 59.0mg/100g) compared to the control (48.20mg/100g) with 95/5 OFSP and germinated *moringa* seed flour having the highest value (59.00mg/100g).

The sample containing 80/20 OFSP and germinated moringa seed flour had the highest concentration of Iron (10.25mg/100g) while 100% OFSP had lowest (5.33mg/100g). The 80/20 OFSP and germinated *moringa* seed blend also contained the highest value for zinc (6.0mg/100g) while 90/10 OFSP and germinated moringa seed flour had the lowest content (4.09mg/100g). The values increased with increment in moringa seed flour and were significantly higher than that of the control. Zinc is important in the production of insulin while iron together with hemoglobin help in oxygen transport (Okwu, 2005). This is an indication that these biochemical processes may be promoted better in children fed with these diets. The composite flours developed from OFSP and germinated moringa seed flour generally contained more minerals than Nestlé CERELAC. All the samples were significantly different at $p<0.05$. The mineral contents of the composite samples were generally higher than that of moringa and moringa cake flour (Abiodun *et al.,* 2012), indicating that OFSP also contributed considerably to the mineral content.

Contribution of the samples to the Recommended Daily Allowance (RDA): The contribution of the samples to the RDA of minerals for infants from six months is presented in Table 1. The calculated contribution of the samples to the RDA for calcium, magnesium, phosphorus, Iron and zinc was in the range 18.6- 19.5%; 30.1- 33.1%; 5.34 -5.9%; 27-51.25% and 24.54-120%, respectively.

Concentration of Water Soluble Vitamins: The result for the water-soluble vitamins is given in Table 2. The average thiamine values for the samples ranged between 0.041- 0.042µg/100g, with no significant difference among the blends. The values decreased with increasing amount of moringa seed flour and were higher than the control (Nestlé CERELAC) (0.04065µg/100g). All obtained values were significantly lower ($p≤0.05$) than the RDA of 0.5mg/day (Lindsay, 2003).

The riboflavin contents ranged from 4.61 - 6.44 µg/100g. The control had 4.74 µg/100g of the vitamin. These values are also quite low with respect to the RDA of 0.5mg/day of infants (Lindsay, 2003). The mean values obtained for niacin (7. 48 mg/ 100 g - 11.42 mg/100 g) were significantly higher ($p \leq 0.05$) than the control (3.41 mg/100 g) and would adequately contribute to the RDA of infants (6 mg/day). Niacin assists in building cell tissues, body's resistance to infections and healing of wounds (Amadi *et al.,* 2012).

The biotin contents were generally higher than that of the control (9.79 mg/100g) with the exception of 90/10 OFSP and germinated moringa seed flour having the lowest biotin content (9.60 mg/100g). Sample containing 80/20 OFSP and germinated moringa seed flour had the highest value of 12.47 mg/100g. The sample containing 80/20 OFSP and germinated moringa seed flour recorded the highest content of biotin (12.47 mg/100g). The samples would contribute over 100% to the RDA of infants (8µg/day). The values within 9.40-11.49 mg/100g were obtained for pyridoxine content of the composite flours while the control had a lower content of 8.50 mg/100g. The values are considerably higher than the RDA of 0.5mg for infants (Lindsay, 2003).

The samples were also considerably rich in folate with recorded values higher than those of the control sample which had 0.21 mg/100g. The sample containing 80/20 OFSP and germinated moringa seed flour had the highest folate content while 100% OFSP had the lowest value. This might be due to increased addition of germinated moringa seed flour and the folate content in OFSP might have also reduced owing to blanching. Cooking can reduce the levels of folate in foods as it has been reported to be vulnerable to heat and dissolves in water (Ekwuagwu *et al.,* 2008).

Vitamin C content of the samples tended to increase on addition of moringa seed flour from 0.11 mg/100g to 0.22 mg/100g but decreased after 10% inclusion. There were significant differences ($p \leq 0.05$), among all the samples. The values for all samples were generally higher than that obtained for the control, (0.17 mg/100g). The average composition is much lower than the vitamin C content (2.65-6.85 mg/100g) of Madiga made from Wheat-Sweet potato composite flours (Idolo, 2011). Vitamin C is important for the manufacture of collagen and in maintaining healthy skin, bones and muscles (Amadi *et al.,* 2012).

Thiamine, riboflavin and niacin of the developed samples relatively decreased on inclusion of germinated moringa seed flour while the biotin, pyridoxine and folate contents increased. The values obtained for the complementary flour samples were generally higher than that of the control with biotin being most abundant in all samples. Water-soluble vitamins are those micronutrients that can be easily lost during processing but are needed to protect the body from various diseases and to facilitate the functioning/metabolism of various body systems (Abidin and Amoaful, 2015). Deficiencies in these vitamins result in the condition termed hidden hunger (UNICEF, 2013) which could manifest itself in several clinical symptoms such as beri-beri for thiamine, neurological problems when deficient in pyridoxine, pellagra in the case of niacin deficiency among others.

CONCLUSION

The Orange Fleshed Sweet Potato germinated moringa seed flour blends (100g) would adequately meet the RDA for iron, zinc and magnesium while higher amounts of the diets would be required to meet that of calcium and phosphorus. In most cases, the samples had higher concentrations of mineral and water soluble vitamins than Nigerian Nestlé CERELAC. Thus, the samples could serve as cheaper means of healthy complementary feeding. The blends could be prepared into porridge with the inclusion of other ingredients to diversify the diet or increase the nutrient content.

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Table 1: Mineral composition (mg/100g) of orange fleshed sweet potato and germinated moringa seed flour blends compared to RDA

Minerals	Calcium	Magnesium	Phosphorus	Iron	Zinc
***RDA**	400	5.00	300	6.00	4.00
$O_{100}M_0$	$248.08^{e}\pm0.02$	$44.10^{a}\pm0.01$	$57.20^{b}\pm0.03$	$5.33^{e}\pm0.00$	$4.21^{b}\pm0.00$
$O_{95}M_5$	$253.01^{d}\pm0.01$	$40.08^{c}\pm0.06$	$59.00^{a}\pm0.03$	$6.15^{d}\pm0.00$	$4.60^{b}\pm0.00$
$O_{90}M_{10}$	$257.11^{b}\pm0.01$	$42.46^{b}\pm0.00$	$53.40^{c}\pm0.03$	$7.91^{c}\pm0.01$	$4.09^{b}\pm0.01$
$O_{85}M_{15}$	$259.10^{a}\pm0.00$	$43.02^{a}\pm0.00$	51.90 ± 0.01	$8.83^{b}\pm0.00$	$4.10^{b}\pm0.00$
$O_{80}M_{20}$	$255.06^{c}\pm0.13$	$40.15^{c}\pm0.02$	54.10 ± 0.23	$10.25^{a}\pm0.02$	$6.00^{a}\pm0.03$
Control	$108.14^{f}\pm0.03$	$39.18^{d}\pm0.01$	48.20 ± 0.01	$8.83^{b}\pm0.01$	$3.08^{c}\pm0.16$

Values are means of triplicate determinations. Within each column, values with different superscript differ significantly ($p<0.05$)

$O_{100}M_0$ - 100% OFSP and 0% Germinated moringa seed flour, $O_{95}M_5$ - 95%OFSP and 5% Germinated moringa seed flour, $O_{90}M_{10}$ - 90% OFSP and 10% Germinated moringa seed flour, $O_{85}M_{15}$ - 85% OFSP and 15% Germinated moringa seed flour, $O_{80}M_{20}$ - 80% OFSP and 20% Germinated moringa seed flour, Ca- Calcium; Mg- Magnesium; P- Phosphorus, Fe- Iron, Zn- Zinc, *RDA- Recommended Dietary Allowance, adapted from Solomon (2005).

Table 2: Water soluble Vitamins of composite flour samples

Sample	Thiamin (ug/100g)	Riboflavin (ug/100g)	Niacin (mg/100g)	Biotin (mg/100g)	Pyridoxine (mg/100g)	Folate (mg/100g)	Cobala-mine	VitaminC (mg/100g)
$O_{100}M_0$	$0.041^{a}\pm0.00$	$5.53^{d}\pm0.01$	$10.68^{b}\pm0.01$	$11.81^{c}\pm0.00$	$10.60^{b}\pm0.01$	$0.27^{e}\pm0.00$	ND	$0.11^{e}\pm0.00$
$O_{95}M_5$	$0.042^{a}\pm0.00$	$6.25^{b}\pm0.11$	$9.14^{c}\pm0.01$	$12.10^{b}\pm0.05$	$9.40^{e}\pm0.02$	$0.28^{c}\pm0.00$	ND	$0.16^{cd}\pm0.00$
$O_{90}M_{10}$	$0.041^{a}\pm0.00$	$6.44^{a}\pm0.23$	$11.42^{a}\pm0.01$	$9.60^{f}\pm0.06$	$11.49^{a}\pm0.00$	$0.31^{b}\pm0.00$	ND	$0.22^{a}\pm0.00$
$O_{85}M_{15}$	$0.041^{a}\pm0.00$	$5.71^{c}\pm0.01$	$8.60^{d}\pm0.00$	$10.70^{d}\pm0.05$	$9.80^{d}\pm0.01$	$0.27^{d}\pm0.02$	ND	$0.17^{bc}\pm0.00$
$O_{80}M_{20}$	$0.041^{a}\pm0.00$	$4.61^{f}\pm0.11$	$7.48^{e}\pm0.01$	$12.47^{a}\pm0.06$	$10.40^{c}\pm0.00$	$0.33^{a}\pm0.00$	ND	$0.09^{f}\pm0.00$
Nestle Cerelac	$0.041^{a}\pm0.00$	$4.74^{e}\pm1.61$	$3.41^{f}\pm0.03$	$9.79^{e}\pm0.06$	$8.50^{f}\pm0.23$	$0.21^{f}\pm0.00$	ND	$0.17^{c}\pm0.01$

Values are means of triplicate determinations. Within each column, values with different superscript differ significantly ($p<0.05$)

$O_{100}M_0$ - 100% OFSP and 0% Germinated moringa seed flour, $O_{95}M_5$ - 95%OFSP and 5% Germinated moringa seed flour, $O_{90}M_{10}$ - 90% OFSP and 10% Germinated moringa seed flour, $O_{85}M_{15}$ - 85% OFSP and 15% Germinated moringa seed flour, $O_{80}M_{20}$ - 80% OFSP and 20% Germinated moringa seed flour, ND- Not Detected