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Physical and chemical characteristics of moringa - fortified orange sweet potato flour for complementary food

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Abstract

Infants from the age of 6 to 12 months are vulnerable to malnutrition in developing countries, especially Vitamin A and other micronutrient deficiencies, due to inadequacy of breast milk and supply of insufficient nutrients through local diets such as poridges made from plain cereals. The aim of this study was to develop complementary food from composite flours of sweet potato (Ipomoea batatas L.) with orange flesh (OFSP), which is rich in beta carotene and germinated moringa (Moringa oleifera Lam.) seed which is rich in protein. Five 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. The physical properties of the composite flours were evaluated and chemical analyses were carried out. Result of preliminary study showed that the beta carotene content of dehydrated OFSP paste obtained by mashing of cooked sweet potato slices (14.66 mg/100g) was lower than the flour of blanched, dried and milled OFSP chips (14.82 mg/100g). The OFSP flour was thus used in the preparation of five mixtures with different proportions of moringa seed flour. The carbohydrate, fat, protein, crude fibre and ash contents of OFSP-Moringa complementary blends were in range: 78.03% - 65.35%; 7.85% - 11.55%; 4.38% - 13.13%, 0.90% - 0.92% and 1.13% - 2.55%, respectively. The protein, fat and ash content of the research blends increased with increasing amounts of germinated moringa seed flour. A daily intake of 30g tested flour mixtures, regardless of composition, due to high value of Vitamin A (413-487.00 µg Retinol Activity Equivalents- RAE), can meet 100% of the recommended dietary allowance of vitamin A (400-500 µg RAE) for infants (6-12months). This study has shown the physical and chemical characteristics of five mixtures of sweet potato and moringa seeds flours as complementary blends. Compared to the control (Nigerian Nestle cerelac) they were showed favourably, especially blend of 80% OFSP and 20% germinated moringa seed flour and could therefore serve as a cheaper and healthier substitute for complementary feeding.

Key words: *Functional characteristics, Chemical characteristics, Moringa seed (Moringa oleifera Lam.), Orange Fleshed Sweet Potato (Ipomoea batatas (L.) Lam), Complementary Food*

Introduction

The challenge of food insecurity in developing countries and the world at large is of growing concern (IFPRI, 2015). Nigeria was reported to have the highest number of neonatal and maternal deaths in Africa and the second highest number of neonatal deaths globally; with about 8% of the world's neonatal deaths and approximately 1 in every 9 maternal deaths occurring in the country (UNICEF, 2012). This morbidity rate is associated with the increasing incidence of food insecurity including protein energy malnutrition and micronutrient deficiencies amongst mothers and children in Nigeria (Ubesie and Ibeziakor, 2012; IFPRI, 2015). Complementary feeding is the process starting when breast milk alone is no longer sufficient to meet the nutritional requirements of infants so that other foods and liquids are needed, along with breast milk (WHO, 2002). Foods other than breast milk given to children after 4 or 6 months of their life are called complementary foods. Fortified nutritious complementary foods are unaffordable by most Nigerian families. Many families thus depend on inadequately processed traditional foods consisting mainly of un-supplemented cereal porridges made from maize, sorghum and millet (Agbon et al., 2009).

Sweet potato [*Ipomoea batatas* (L.) Lam.] orange flesh cultivars (OFSP) is an important naturally bio-fortified crop with great potentials to be used in food-based intervention programs to address vitamin A deficiency (Henok, 2015). It can provide β-carotene in sufficient amounts to meet the Recommended Dietary Allowance (RDA) of vitamin A in the diet (Tumwegamire et al., 2004).

Moringa (*Moringa oleifera* Lam.) is the most widely cultivated species of the monogenus family of Moringaceae (Fuglie, 2001). According to Ijarotimi et al. (2013), the seed of this plant contains a profile of important minerals, vitamins, amino acids, fatty acids, beta-carotene, and various phenolics and phytochemicals that can be employed in nutrition and medicine. The plant has been found to be of good nutritional profile (Mbah et al., 2012) and the inclusion of moringa seed flours into food products was found to increase the nutritional value in terms of protein, crude fibre, ash and mineral contents (Olosunde et al., 2014; Alabi et al., 2015). This study is therefore aimed at developing complementary food from tested blends of OFSP and germinated moringa seed flours and assessing some of the quality parameters.

Materials and Methods

Sweet potato storage roots with orange flesh (*mothers' delight*) were gotten from a local farm in Agbamu area of Kwara State. The moringa seeds were collected from a house farm in Tanke Bubu area in Ilorin metropolis, Kwara state. Nestle cerelac used as control was obtained from a local market in Ilorin, Kwara state.

A preliminary experiment was carried out using two different processing methods to determine the best method that will give higher beta carotene retention. OFSP roots were washed with clean tap water to remove adhering soil particles and other unwanted materials. The roots were peeled and sliced into 2.5-3.0 mm thickness (measured using a vernier caliper). In the first method, 10 g of the slices was steam cooked for about 10 min. The cooked OFSP was then mashed into a paste using mortar and pestle. The paste was spread as thin as possible and dried at 60°C for 60 min in a fabricated cabinet dryer (Food and Bioprocess Engineering Department, University of Ilorin). Another portion of 10 g of OFSP slices was blanched at 80°C for 2 min to inactivate browning enzymes. The drained cool slices were dried in the cabinet dryer (60°C for 4 hours). Dryness was measured by the crispness of the chips. The chips were afterwards milled into flour and both samples were tested for beta carotene content on the same day of production. The method with the higher beta carotene content was adopted and used for the study.

Moringa seeds (500 g) were subjected to germination using the method described by Ijarotimi et al. (2013) and Alabi et al. (2015) with slight modifications. The seeds were carefully sorted to remove unwanted materials including damaged seeds. After sorting, the seeds were soaked in 1500 ml distilled water for 24 hours (Alabi et al., 2015) to absorb enough moisture for germination. The soaked seeds were properly drained and then spread on a wet clean jute bag, covered with a wet clean white muslin cloth and another layer of wet jute bag. Germination was done for 4 days (Ijarotimi et al., 2013) in a dark area. After germination, the seeds were dehulled and air dried for 4 days.

Formulation of flour blends

The composite flours were formulated from OFSP flour (O) and germinated moringa seed flour (M) in the five proportions (%): 100:0 ($O_{100}M_0$), 95:5 ($O_{95}M_5$), 90:10 ($O_{90}M_{10}$), 85:15 j6($O_{85}M_{15}$) and 80:20 ($O_{80}M_{20}$), respectively, while Nestle cerelac (instant cereals suitable for infant complementary food) was used as control.

Basic chemical composition of flour blends: The basic chemical composition (moisture, dry matter, proteins, fat, ash, crude fibre and carbohydrates, also energy value) of researched blends of flours and control was determined using the methods described by AOAC (2000). Carbohydrate content was determined by subtracting other basic chemical parameters from a total of 100 nutrient value i.e [100- (protein + fat + ash + crude fibre + moisture)] while the energy value was calculated using the calorie conversion factors of 4, 9 and 4 for carbohydrate, fat and protein respectively.

Physical analysis

Bulk density was determined using the method described by Okezie and Bello (1998) and calculated by values of volume before and after tapping in relation to weight of lossened and compactened bulk of samples. Oil and water absorption capacities expressed in (ml/g) were determined using the method of Beuchatt (1977). The method of Onwuka (2005) was adopted for gelatinization temperature while the hydration index was determined following the procedure of Narayana and Narasinga (1982).

Beta-Carotene and Lycopene

The determination of beta carotene and lycopene was done according to the method of Kumara et al. (2011). Dried sample was extracted using methanol and extract (100mg) was mixed with 10 ml of acetone-hexane mixture (4:6) for 1 minute and filtered. The absorbance was recorded at wavelengths of 453, 505 and 663 nm and calculated thus:

Beta carotene (mg/100ml) = 0.216 x A663 – 0.304 x A505 + 0.452 x A453

Lycopene (mg/100ml) = -0.0458 x nA663 + 0.372 x A505 – 0.0806 x A453

The Vitamin A contribution to the diet was calculated using conversion values where 12 μg β-carotene is equal to 1 μg Retinol Activity Equivalents - RAE (Tadesse et al., 2015).

Statistical Analysis

The data were analysed by analysis of variance (ANOVA) using Statistical Package for Social Sciences (SPSS) version 16.0 to determine the mean values, standard deviation and significant differences among the treatments. Following the significant *F*-test, means were compared using Duncan's multiple range test ($P \leq 0.05$).

Results and Discussion

Preliminary study

The result of the beta carotene analysis of the OFSP dehydrated paste and flour is presented in Table 1. The beta carotene content of dehydrated OFSP paste (14.66 mg/100g) was lower than of flour of blanched, dried and milled OFSP chips (14.82 mg/100g), though not significantly. Steam cooking have been found to retain more beta carotene than other methods (Sinha et al., 2015; Tumuhimbise et al., 2009), but in this study the steam cooked sample was further dried in to flour (OFSP dehydrated paste) and this might have resulted into the lower beta carotene content recorded. Due to higher content of beta carotene, OFSP flour was used in this study for preparation five blends with different proportions of moringa seeds flour.

Table 1 *Betacarotene content of dehydrated paste and flour of orange flesh sweet potato (OFSP)*

Dehydrated OFSP	Beta carotene (mg/100g)
Paste	14.66 ± 0.03^a
Flour	14.82 ± 0.19^a

Values with same superscript do not differ significantly ($p \leq 0.05$)

Physical characteristics

The results of physical characteristics of flour blends are presented in Table 2. The bulk densities of loosened and compactened (LBD and CBD) bulk of the treatments were between 0.37 to 0.44 g/ml and 0.50 to 0.63 g/ml at $O_{80}M_{20}$ and $O_{100}M_0$,respectively. The values are comparable with that of the control (0.42 g/ml and 0.53 g/ml for LBD and CBD). Similar trend was reported by Desalegn et al. (2015) for Quality Protein Maize-based complementary foods with values 0.91 to 1.19 g/ml. High bulk density reduces the nutrient intake per feed for infants (Ikujenlola et al., 2013), therefore, the low packed bulk density obtained in the blends could assist in providing adequate nutrients in smaller volume.

The oil absorption capacity (OAC) ranged from 0.42 ml/g for flour blend $O_{80}M_{20}$ to 0.714 ml/g for $O_{100}M_0$ and 0.83 ml/g at $O_{85}M_{15}$. All treatments, except $O_{85}M_{15}$, had significantly lower values of OAC then pure sweet potato flour and statisticaly equal or lower than control. Mainly, the OAC decreased with addition of germinated moringa seed flour. This might be associated with the fat content of the moringa seed flour. OAC is attributed to the retention of flavour by products (Desalegn et al., 2015).

The control had the highest water absorption capacity (WAC) of all tested samples with a value of 0.22 ml/g, but statistically equal with treatments $O_{85}M_{15}$, $O_{80}M_{20}$ and $O_{100}M_0$ (0.22, 0.20 and 0,19 ml/g, respectively). while $O_{90}M_{10}$ and $O_{95}M_{15}$ belonged to the rank with least values (0.15 and 0.14 ml/g). High WAC limit the absorption of nutrients as it contributes to bulkiness of food (Ikujenlola et al., 2013). Therefore, the low WAC obtained for the composite blends is desirable for complementary foods.

Values within 1.10 and 1.59% were obtained for Hydration Index (HI) with $O_{95}M_5$ recording the highest while $O_{85}M_{15}$ and $O_{80}M_{20}$ had the lowest same value. The HI tends to decrease gradually with increase in moringa seed incorporation. These values are comparable to the value range of 1.36 - 1.75% reported by Amajor et al. (2014) for fermented sundried OFSP flour. Hydration index, otherwise known as swelling index, is a determining factor of how much water would be absorbed by a food (Olaitan et al., 2014). The low hydration index as obtained in this study is desirable for complementary foods as this suggests that more nutrients would be taken per volume consumed.

The gelatinization temperature (GT) of researched blends ranged from 82.8 - 85.9 °C for $O_{85}M_{15}$ and $O_{90}M_{10}$, while the control recorded 90.6 °C. The values obtained in this report are lower than the values of 89.0°C and 87.5°C reported by Amajor et al. (2014) for fermented sundried OFSP flour. GT is that temperature at which the starch granules in a heated food becomes disrupted and forms a gel. The lower GT of the OFSP-germinated moringa seed blends compared to the control suggests that they would require lower energy cost during processing into ready to eat products.

***Table 2.** Physical characteristics of sweet potato and moringa flour blends*

Parameter	$O_{100}M_0$	$O_{95}M_5$	$O_{90}M_{10}$	$O_{85}M_{15}$	$O_{80}M_{20}$	Nestle Cerelac
LBD (g/ml)	0.44^a	0.42^a	0.38^b	0.38^b	0.37^b	0.42^a
CBD(g/ml)	0.630^a	0.56^b	0.51^b	0.51^b	0.50^b	0.53^b
OAC (ml/g)	0.71^b	0.56^c	0.56^c	0.83^a	0.42^d	0.56^c
WAC (ml/g)	0.16^{ab}	0.14^b	0.15^b	0.20^a	0.19^a	0.22^a
HI	1.32^{ab}	1.59^a	1.13^b	1.10^b	1.10^b	1.43^a
GT (◦C)	84.2^b	85.7^b	85.9^b	82.8^c	85.5^b	90.6^a

Within each co*lumn, values with different superscript differ significantly ($p \le 0.05$)*
O100M0 -100% orange flesh sweet potato
O95M5 -95% orange flesh sweet potato and 5% germinated moringa seed flour
O90M10-90% orange flesh sweet potato and 10% germinated moringa seed flour
O85M15- 85% orange flesh sweet potato and 15% germinated moringa seed flour
O80M20-80% orange flesh sweet potato and 20% germinated moringa seed flour
Control - (Nestle Cerelac)
LBD- loosened *bulk density, CBD- compactened bulk density, OAC- oil absorption capacity, WAC- water absorption capacity, HI- hydration index, GT- gelatinization temperature*

Basic chemical composition

The basic chemical composition of the flour blends is given in Table 3. The moisture contents of the flour blends ranged from 5.90% for $O_{85}M_{15}$ to 7.87% for $O_{90}M_{10}$ treatment. This is significantly higher than that of Nestle cerelac (2.10%). The moisture content is higher than 3.70 to 5.15% reported by Solomon (2005) for complementary foods based on cereals and legumes. The results are lower than the 10% recommended for long term storage (Van Hal, 2000). In a contrasting trend, the values obtained for the dry matter content varied ranged from 92.10% for $O_{90}M_{10}$ to 94.07% for $O_{85}M_{15}$, and they were significantly lower than the control (97.90%). It is a reflection of the nutrient density of food materials and these values indicate that the researched blends of OFSP and germinated moringa seed flour are still rich in nutrients.

The protein content in flour blends was in rangefrom 4.37% ($O_{100}M_0$) to 13.13% ($O_{80}M_{20}$). It increased with increasing amount of moringa seeds flour and this might be due to the protein content of the incorporated moringa seed (Abiodun et al., 2012). The trend of values obtained are comparable to that (6.37% to 7.88%) reported by (Anigo *et al.,* 2010) for complementary foods containing malted maize, millet and sorghum with groundnut and soyabean. These values also fall within 5% to 14.9% obtained for Acha-wheat biscuits supplemented with soybean flour (Ayo et al., 2007). Sample containing 20% germinated moringa seed had the highest protein content and met the Recommended Dietary Allowances (RDA) of 13-14g/day of protein for infants (Guthrie, 1989). The intake of protein-rich complementary foods is important in decreasing protein energy malnutrition in infants (Odebode and Odebode, 2005).

The fat content of the flour blends was in range from 7.80% to 11.54% for $O_{90}M_{10}$ and $O_{80}M_{20}$, respectively. The values of fat content of all researched flour blends were higher than obtained for Nestle cerelac (7.27%). The values were higher than 4.68- 5.74% and 1.05%-2.06% reported for Quality Protein Maize (QPM) based complementary foods and complementary diets made from malted maize, millet and sorghum with groundnut and soya beans, respectively (Desalegn et al., 2015; Anigo et al., 2010). On contrast, the fat contents were lower than (15.6%-38.1%) reported by Solomon (2005) for complementary foods based on cereals and legumes (rice, maize, Acha grains, soyabeans, groundnut, Bambaranut, benniseed, carrot, garden egg and crayfish). This is probably due to the higher combination of oil seeds such as soybeans and groundnut in the diet formulations. Fat is usually recommended to be included in infant diet because it contributes to the energy value/nutrient density (Solomon, 2005). The fat content of the researched flour blends would satisfy the minimum RDA of fat (10-25g) for infants up to a year (Guthrie, 1989).

The ash contents of the flour blends were comparable ($p<0.05$) to that of the Nestle Cerelac (1.95%) with values ranging from 1.14% ($O_{100}M_0$) to 2.55% ($O_{80}M_{20}$). The values increased on addition of the germinated moringa flour portions. Alabi et al. (2015) has reported germinated moringa seed as fortifying agent. The ash values are comparable to results (1.61%-3.07%) of Desalegn et al., (2015) for QPM based complementary foods. Ash content is a measure of the mineral composition of foods. They are important in fighting infections and for other metabolic activities in infants (Abidin and Amoaful, 2015). The values obtained in this study indicate that the researched flour blends might contain appreciable amount of important minerals for proper growth and development.

The values obtained for the crude fibre of all tested flour blends and control were statistically equal in the range from 0.90 to 0.91%. This result is lower that the crude fibre content of biscuits supplemented with moringa leaves and cocoa powder (Ajibola et al., 2015). The values are within the range of less than 5% fibre content recommended for infant feeding (Alvisi et al., 2015). The crude fibre content of complementary foods should be low as increased fibre may increase the bulkiness and results in low caloric intake from other nutrients (Alvisi et al., 2015). The researched flour blends thus had crude fibre contents that would allow for the consumption of other important nutrients in the diet.

The carbohydrate content of researched flour blends decreased from 78.03% for $O_{100}M_0$ to 65.35% for $O_{80}M_{20}$. The values decreased on addition of germinated moringa seed flour while that obtained for the control (78.77%) was the statistically highest. This might be due to the lower content of other nutrients (protein, fat and ash) in the dry matter of 100% OFSP flour while blends with moringa seed has increased content of other nutrients and a corresponding decrease in the carbohydrate values recorded. Starch content in form of carbohydrate is an important factor that determines the textural, rheological and physicochemical properties of sweet potato for industrial applications including the production of complementary foods (Sanoussi et al., 2016). The energy values of 100 g researched flour blends ranged from 398.45kcal for $O_{90}M_0$ to 420.36kcal for $O_{85}M_{15}$ while the control had 416.63kcal. From the results obatined, it is observed that $O_{85}M_{15}$ and $O_{80}M_{20}$ had significantly higher energy values compared to the control, while the other blends ($O_{90}M_{10}$, $O_{95}M_5$ and $O_{100}M_0$) had lesser energy values.

The energy value increased while the amount of OFSP in the formulations decreased. The increase in energy content on inclusion of germinated moringa seed flour might be due to the fat contribution of moringa seeds (Abiodun et al., 2012) to the blends. This is confirmed by the increasing fat contents of the blends as moringa seed flour increased. The stomach size of infants allows them to consume limited amount of foods at a time and it is thus important to supply them with energy rich foods that would sufficiently meet their growth requirements (Rondo et al., 2008).

Table 3 *Basic chemical composition of sweet potato and moringa flour blends*

Nutrient	$O_{100}M_0$	$O_{95}M_5$	$O_{90}M_{10}$	$O_{85}M_{15}$	$O_{80}M_{20}$	Nestle Cerelac
Moisture (%)	6.85 ^{b}	6.65 ^{c}	7.87 ^{a}	5.90 ^{e}	6.50 ^{d}	2.10 ^{f}
Drymatter (%)	93.15 ^{d}	93.35^{cd}	92.10 ^{e}	94.07^b	93.50^c	97.90^a
Protein (%)	4.37 ^{f}	4.81 ^{e}	6.56 ^{d}	7.22 ^{c}	13.13^a	8.97^b
Fat (%)	8.67 ^{d}	9.37 ^{c}	7.80 ^{e}	10.80^b	11.54^a	7.27 ^{f}
Ash (%)	1.14^f	1.21^e	1.39 ^{d}	1.59^c	2.55^a	1.95^b
CF (%)	0.90^b	0.91^{ab}	0.90^b	0.90^b	0.91^{ab}	0.91^{ab}
CHO (%)	78.03^b	76.96^c	75.40^d	73.58^e	65.35 ^{f}	78.77^a
Energy (kcal)	407.92^e	411.81 ^{d}	398.45 ^{f}	420.36^a	417.87^b	416.63 ^{c}

Within each column, values with different superscript differ significantly ($p\leq0.05$)
O100M0 -100% orange flesh sweet potato

O95M5 -95% orange flesh sweet potato and 5% germinated moringa seed flour
O90M10-90% orange flesh sweet potato and 10% germinated moringa seed flour
O85M15- 85% orange flesh sweet potato and 15% germinated moringa seed flour
O80M20-80% orange flesh sweet potato and 20% germinated moringa seed flour
Control - (Nestle Cerelac)
CHO- carbohydrate, CF- crude fibre

Beta Carotene and Lycopene

The results for the beta carotene and lycopene content of the researched flour blends are shown in Table 4. All researched flour blends had significantlly higher beta carotene content compared to the control (2.07 mg/100g). The flour blend $O_{90}M_{10}$ had the highest beta carotene content (18.81 mg/100 g) which was statisticaly equal (comparable) with values obtained for blends $O_{100}M_0$ and $O_{95}M_5$ (17.87 and 17.56 mg/100 g). Beta-carotene is converted to the active form of vitamin A in the body. As a standard, 12μg β-carotene is equal to 1 μg Retinol Activity Equivalent-RAE (Tadesse et al., 2015).

The lycopene content of the researched flour blends were in range from 5.95 to 6.87 mg/100 g and also had higher values in relation to the control. These values are comparable to the lycopene content of raw tomatoes (5.14- 5.67 mg/100 g) but lower than the values (10.38-11.12 mg/100 g) of tomato based juices (Adubofuor et al., 2010). This might be responsible for the reddish orange colour of the OFSP based composite flour whereas the control was rather creamy in colour. From this, it is shown that OFSP is also a good source of lycopene which is an important carotenoid associated with several health benefits (Cushing et al., 2008). In addition, it could be an indicator of the colour of products and the subsequent acceptance by consumers especially children.

Contribution of the Samples to the Recommended Dietary Allowance

The contribution of average meal (30 g) of the researched blends to the RDA of vitamin A for infants from six months is presented in Table 4. The beta carotene content of the researched flour blends would contribute 82.8 to 117.6% to the RDA of Vitamin A for infants (6-12months). Average meal (30 g) of blend $O_{90}M_{10}$ due to the highest content of beta carotene ensured the highest value of vitamin A (470.25 μg RAE) which represents 94.1 – 117.6 % RDA of vitamin A for 6-12 months infants (400-500 μg RAE). The control on the contrast would contribute the lowest percentage to the RDA (10.4 – 51.8%) on an average meal (30g) consumption due to the lower content of Vitamin A recorded (172.5 μg RAE). Vitamin A is an important nutrient that helps strengthen the immune system of infants against several infections and maintains the integrity of the epithelial linings (Ekweagwu et al., 2008).

Table 4. *Lycopene and beta carotene content of sweet potato and moringa flour blends with estimated contribution of average meal (30g) to RDA of Vitamin A for infants of 6-12 month*

Blends	Samples 100 g			Samples 30 g	
	Lycopene (mg)	Beta carotene (mg)	Vitamin A (μg RAE)	Vitamin A (μg RAE)	% RDA of vitamin A
$O_{100}M_0$	6.414±0.30^a	17.87 ±0.05^{ab}	1489.17±38.83^b	446.75±11.65^b	89.4 – 111.7
$O_{95}M_5$	6.872±0.16^a	17.56 ±0.03^{ab}	1463.33±2.15^b	439.00±0.64^b	87.8 – 109.8
$O_{90}M_{10}$	5.952±0.18^a	18.81±0.24^a	1567.50±19.68^a	470.25±5.90^a	94.1 – 117.6
$O_{85}M_{15}$	6.085±0.02^a	16.56 ±0.31^b	1380.00±25.97^c	414.00±7.79^c	82.8 – 103.5
$O_{80}M_{20}$	6.312±0.60^a	19.48 ±0.89^a	1623.33±23.40^a	487.00±7.07^a	97.4– 121.8
Nestle Cerelac	0.00	2.07±0.15^c.	172.5±12.11^d	51.75±5.20^d	10.4 – 51.8

Within each column, values with different superscript differ significantly (p≤0.05)
O100M0 -100% orange flesh sweet potato
O95M5 -95% orange flesh sweet potato and 5% germinated moringa seed flour
O90M10-90% orange flesh sweet potato and 10% germinated moringa seed flour
O85M15- 85% orange flesh sweet potato and 15% germinated moringa seed flour
O80M20-80% orange flesh sweet potato and 20% germinated moringa seed flour

Control - (Nestle Cerelac)

The obtained values of beta carotene and lycopene in mg/100ml were converted to mg/100 g. *1 μg RAE=12 μg β-carotene *RDA- Recommended Dietary Allowance of Vitamin A for 6-12 months infants (400-500 μg RAE)

Conclusions

The flour blends from OFSP and germinated moringa seed (especially $O_{80}M_{20}$) were found to be comparable to Nestle cerelac in physical characteristics (such as bulk densities, hydration index and gelatinization temperature). In terms of chemical composition, the research blends were observed to be better particularly in protein, fat, ash and beta carotene contents. The blends (especially $O_{80}M_{20}$) could therefore serve as cheaper source of important nutrients (such as protein and Vitamin A) and as healthy substitutes for complementary foods. It is thus recommended that further research on the nutritional profiles and storage shelf life should be conducted to widen the understanding of their potential benefits in infant food preparation.

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