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NUTRITIONAL, PASTING AND SENSORY PROPERTIES OF A WEANING FOOD FROM RICE *(ORYZA SATIVA)*, SOYBEANS *(GLYCINE MAX)* AND KENT MANGO *(MANGIFERA INDICA)* FLOUR BLENDS

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ABSTRACT

The effective use of readily available and inexpensive sources of protein and micronutrients has become a major focus of research in recent years. This study sought to provide a nutritionally adequate and culturally acceptable weaning food for infants, as well as tap the potential of broken rice fraction as an alternative use for weaning formulation in Ghana. Flour from broken rice fractions in combination with soybeans and dried mangoes were used to develop four weaning formulations. Rice-Soy Mango (RSM) was prepared with 75% rice flour, 25% soybeans flours and 0% mango flour (RSM-0), and used as control; RSM-5 was prepared with 70% rice flour, 25% soybeans flours and 5% mango flour; RSM-10 was prepared with 65% rice flour, 25% soybeans flours and 10% mango flour while RSM-15 was prepared with 60% rice flour, 25% soybeans flours and 15% mango flour. The products were evaluated for their nutritional composition, sensory characteristics and pasting properties. All the three newly formulated rice-mango weaning food met the Estimated Average Requirement (EAR) for energy (393.71-403.25 KCal/100 g), protein (10.7-15.24 g/100 g), carbohydrates (68.44-73.87g/100 g), zinc (8.67-10.84 mg/d and vitamin C (13.96-17.79 mg/100 g) levels but not for iron (3.99-7.61 mg/100 g), fat (6.22-7.61 g/100 g) and calcium (87.2-111.7 mg/100 g). The beta-carotene levels ranged from 74.8 to 346.6 µg/100 g and showed significant differences. The pasting profile for the blends with low amounts of mango (RSM-5 and RSM-10) had a similar profile as the control (RSM-0), while RSM-15 had a lower profile. Among the three newly formulated blends, RSM-10 had the highest peak viscosity (74.0 BU) and highest final viscosity of 107 BU. The RSM-5, RSM-10 and RSM-15 were all lighter than RSM-0, albeit not significant. Increasing the content of mango resulted in the flour blend becoming more yellow. Even though the sensory quality of RSM-5 was the most preferred, there was no significant difference ($p>0.05$) observed between the sensory quality of all the three newly formulated products (RSM-5, RSM-10, RSM-15). The RSM-10 showed great potential and may be recommended and adopted for promotion within Ghanaian households based on its high nutritional and good sensory qualities.

Key words: Weaning, Broken Rice, Mangoes, Pasting, Sensory, Vitamin A, Iron, Children

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INTRODUCTION

The weaning period is the most crucial and vulnerable period for developing children under nutrition [1]. This is because after breastfeeding for six months, additional food and nutrients may be required to continue and maintain the child's growth and development. Unfortunately, during this period, mothers/caregivers give food only to prevent the child from being hungry with little regard to the nutritional quality of the weaning food [1]. This situation worsens if economic challenges exist in the family. During this critical period children develop illnesses and multiple deficiencies such as protein, energy and micronutrient deficiencies. The key limiting nutrients identified during the weaning period are iron, zinc, vitamin B6 and, in some populations, riboflavin, niacin, thiamin, calcium, vitamin A, folate and vitamin C. Vitamin D is also of concern in populations with low exposure to sunshine or at high latitudes [2]. The highest burden of micro-nutrient malnutrition including vitamin A deficiency (VAD), iron and other diseases associated with hidden hunger among children under five is found in sub-Saharan Africa [3].

In Ghana, protein-energy malnutrition and micronutrient deficiency among children, especially those living in rural communities, is estimated to be very high [4]. This is because during this period the traditional weaning food (maize porridge, often referred to as *Koko*) given to the child lacks adequate nutrients for growth and development [5]. To improve the nutrient intake of Ghanaian babies, several strategies have been put in place to help solve the problem of protein-energy malnutrition and micronutrient deficiency. For example, to combat VAD, food ingredients such as flour and vegetable oil have been fortified with vitamin A [6, 7]. Additional strategies that have been experimented include administering vitamin A supplements [8] and bio-fortification with orange-fleshed sweet potatoes [9, 10]. Some studies have also looked at formulation of weaning foods that increase the protein and energy contents but failed to include some micronutrients of health importance [11]. It is important to improve upon both the macro- and micro- nutrients content of traditional weaning foods. A weaning food made from locally available ingredients such as mango (which is rich in vitamin A), soybeans (a source of non-heme iron), and locally grown broken rice fraction may be a cheaper approach to significantly improve the vitamin A and iron contents of weaning foods in Ghana.

Rice is a major staple food all over the world including Africa. It may be a good carbohydrate alternative in weaning food blends. In Ghana, though the production of local rice has been increasing lately, patronage of this local rice is, however, low. This is because the inadequate and inappropriate post-harvest practices currently used by farmers and other rice value- chain actors make the quality of the locally milled rice variable. The level of broken grains after milling usually exceeds 30% and the product contains unhusked grains as well as bran and husk fractions [12]. This broken rice fraction which otherwise may be used as animal feed or left unused could potentially be an alternative source of carbohydrate for novel infant feed formulations.

Soybean is known for its high quality protein and fat content [13]. Its application in weaning formulation improves their protein, fat [14] and iron contents [13].

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Mango *(Mangifera indica)* is one of the most cultivated fruits in the tropics and is patronized in many households in Ghana. The fruit is generally sweet; however, different varieties supply very different flavours to the taste buds. Mangoes contain many phytochemicals (vitamin E, mangiferin) and are high in dietary fiber, vitamin C, beta-carotene (which is a precursor of vitamin A) and a diverse array of polyphenols [15]. One hundred gram of mango provides 765 mg or 25% of the daily vitamin A intake [15]. The Kent variety (used in this study) is reported to contain 5.46 mg/100 g of carotenoids by fresh weight [16]. Beta-carotene, which is the principal carotenoid in mangoes, has a high bioavailability efficiency of 82% [17]. Analysis of different types of mangoes showed a progressive increase in beta-carotene levels as the mango ripens [17]. Studies have also shown a higher serum retinol and beta-carotene levels after consumption of mangoes by children in Senegal [18]. Mangoes also contain 25 g of fiber, which accounts for nearly 20% of the daily fiber intake [15]. It helps prevent constipation and diarrhea. Incorporating mangoes into weaning formulation will, therefore, improve the fiber, vitamin C (which may also enhance the absorption of the non-heme iron in soybeans [19]) and beta-carotene levels, as well as provide natural sweetness and taste to the weaning formulation. The aim of the study was to formulate a weaning food with adequate iron and beta carotene content from broken rice fractions, dried mangoes and soy beans, and to assess its nutritional and sensory qualities.

MATERIALS AND METHODS

Raw Materials and Sample Preparations

Broken rice (*Oryza sativa)*, fractions from two different varieties (var. Togo Marshall and Jasmine) produced in Ghana, soybean (*Glycine max*) and dried mangoes (*Mangifera indica*) were used for the formulation of the weaning food. These were all obtained from an accredited supplier in Accra. The broken rice was winnowed before milling. Partially ripened mangoes were washed under running tap water, peeled and cut into very thin slices (2 mm thick) before drying at 60^0C for 18 hrs in a hot-air oven. Dried mango slices were added to the broken rice fraction, milled using a hammer mill and sieved (250 µm) to obtain fine flour. Five hundred grams of sorted and washed soybean was blanched for 30 min at 100^oC according to methods used by Plahar and Leung [14], allowed to cool at room temperature and dried in an air oven at 60^oC for 8 hr. The dried soybeans were dehulled, winnowed, milled into fine powder (250 µm) and stored airtight in high density polyethylene bags at 4^oC.

Blend formulation and Product development

Four different blend formulations with different percentages of broken rice and mangoes were developed as shown in Table 1. These blends were designated as RSM-0 (control), RSM-5, RSM-10 and RSM-15.

Porridge from Rice-Soy Mango Flour blends

One hundred grams of each blend was mixed in 880 mL of water and stirred to obtain a consistent slurry. One gram of salt and 25 g of sugar were added to the slurry before boiling for 6-8 min into cooked porridges.

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Nutritional Composition of Flour blends

Proximate composition (energy, carbohydrates, protein, fat, and ash), minerals (iron, calcium and phosphorus) and beta-carotene level were determined for each formulation using standard procedures [20]. Beta-carotene levels were then converted to retinol equivalent to estimate the vitamin A/retinol level based on FAO/WHO recommendations [21]. Energy values were determined using Atwater factors 3.47, 8.37 and 4.00 for protein, fat and carbohydrates, respectively [22, 23]. Proximate analysis was carried out in the Chemistry Laboratory of the CSIR-Food Research Institute, Ghana, while Beta-carotene analysis was done at the Nutrition Division of the Noguchi Memorial Institute of Medical Research, Ghana.

Pasting Properties of Flour blends

Pasting properties of flour blends were determined with a Brabender Visco-amylograph (Model VA-VE, Brabender Instruments, South Hackensack, NJ) equipped with a 1000 cmg sensitivity cartridge. A 10% slurry (dry weight basis) of each flour was prepared with distilled water and the slurry heated uniformly (1.5^{0}C per min) from 25 to 95^{o}C and held to cool at the same rate to 50^{o}C [24]. Determination of pasting properties was carried out in the Food Processing Laboratory of the CSIR- Food Research Institute, Ghana.

Sensory Evaluation Studies

Sixty caregivers with children 6-24 months old were made to assess the porridge. They assessed the sensory characteristics of all four formulations. Panelists were asked to rank their preference for porridges made from the blends based on colour, appearance, taste, aroma, mouth feel, after-taste, consistency and overall acceptability on a 9-point hedonic scale [25]. They were also made to indicate their willingness to buy the developed weaning product.

Consent

Permission to carry out this study was sought from the hospital authorities of the University of Ghana, Legon Accra, Ghana to allow the researchers to carry out the study in all the child welfare clinics listed under their various hospital units. At each welfare clinic, permission was sought from the nurses in charge of the clinic. Consent was sought from each participant. The purpose of the study and the benefits were explained to each participant prior to signing of the consent form by the caregivers.

Colour Determination

The colour parameters L*, a* and b* of the flour blends and porridge from these blends were measured with a Minolta CR-310 (Minolta camera Co. Ltd, Osaka, Japan) tristimulus colorimeter. Hue angle, h and color differences ΔE were calculated from L*, a*, b* according to the following formulae [26]:

$$\text{Hue}(h) = arctan\frac{b^*}{a^*} \ \ldots\ldots\ldots\ldots\ldots \quad (1)$$

$$\Delta E = [(L_0-L)^2 + (a_0-a)^2 + (b_0-b)^2]^{1/2} \ \ldots\ldots\ldots \ (2)$$

where L_0, a_0 and b_0 are L^*, a^*, b^* values for RSM-0.

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Data Analysis

Data were analyzed for differences using ANOVA and significantly different means separated using Duncan's Multiple Range Tests (SPSS 17.0.1, SPSS Inc USA). Statistical significance was set at a level of 95% confidence interval. Results were reported as means ± standard error and others illustrated with graphs.

RESULTS

Product Development

The different formulations and product characteristics of the blends, as perceived by the expert panel, are shown on Table 2. The colour of blends and porridges from these blends was characteristic of infant baby formula.

Nutrient Composition of Rice-Soy-Mango Blends

Moisture content of the flours blends ranged between 6.8 - 8.0 % (Table 3). Among the three newly formulated blends, RSM-5 had the highest amount of fat, vitamin C, iron and calcium. Carbohydrates, protein, vitamin C and beta-carotene levels on the other hand, were markedly different ($p<0.05$). This observation may be attributed to the constant proportions of soybean, which mainly supplied the minerals, and varying proportions of broken rice and mango, which served, correspondingly, as the sources of carbohydrates and vitamins.

Pasting Properties

Figure 1 shows that RSM-5 and RSM-10 had a similar pasting profile as the control (RSM-0), while RSM-15 had a lower profile. Pasting indices of flour from the three formulated weaning foods and control are summarized in Table 4. As indicated, the formulations showed differences in some of their viscoelastic properties and similarities in others.

Sensory Evaluation

Table 5 presents the acceptability, degree of liking and limiting sensory factors for the various sensory characteristics of porridges prepared from the Rice-Soy Mango flours. There was no limiting sensory attributes for RSM-5. Panelists made comments such as; "perfect porridge", "excellent porridge", "milky after-taste" thus affirming their preference for RSM-5. Results from sensory evaluation (Table 6) also showed that RSM-5 was the most preferred porridge in terms of taste, after-taste, mouth feel and overall acceptability. Formulations with 15% dried mangoes (RSM-15) gave the least overall acceptability mean of 7.04 ±1.2 (like moderately).

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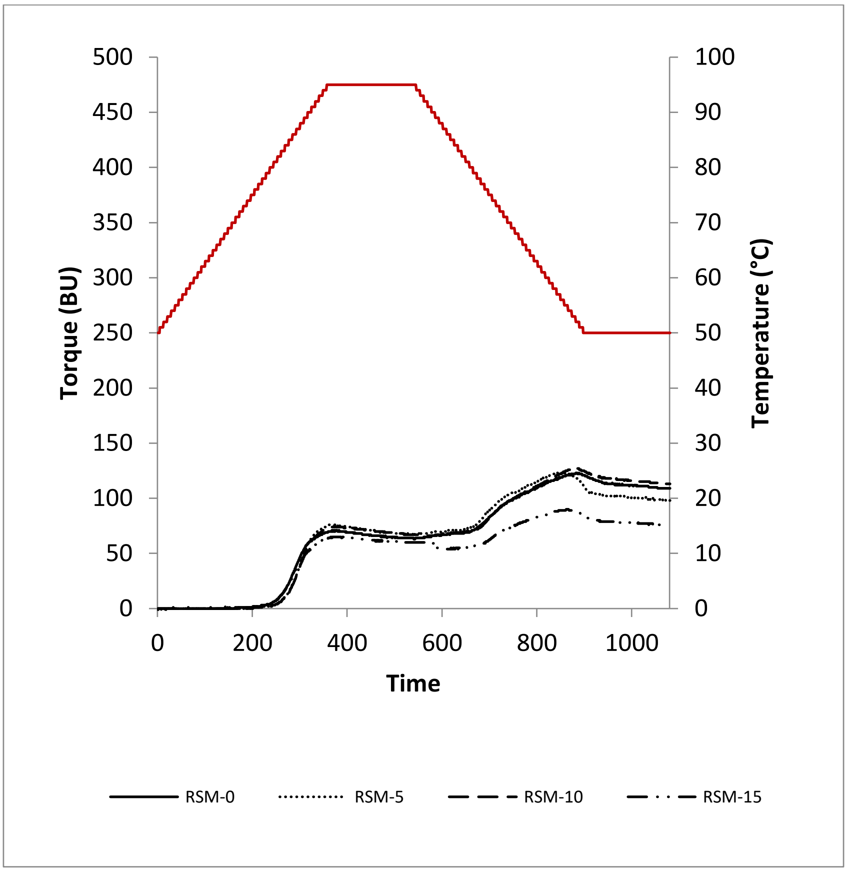

Figure 1: Pasting Profile of the Rice-Soy Mango Blends

Colour Properties

Colour parameters for the flour blends as well as cooked porridge from the different formulae are presented in Tables 7 and 8. The RSM-5, RSM-10 and RSM-15 were all lighter than RSM-0, albeit not significant. The hue angle ranged between 101.43 and 102.57 for the flour blends and was significantly different from one flour blend to another.

DISCUSSION

This study sought to provide a nutritionally adequate (rich in iron and vitamin A) and culturally acceptable weaning food for infants and to explore the potential of broken rice fraction as an alternative use for weaning formulation in Ghana. Flour from broken rice fractions in combination with soybeans and dried mangoes were used to develop three different weaning formulations with one control. The products were evaluated for their nutritional composition, pasting properties and sensory characteristics. All the three newly formulated Rice-Soy Mango blends met the Estimate Average Requirement (EAR) for energy (393.71-403.25 KCal/100 g), protein (10.7-15.24 g/100 g), carbohydrates (68.44-73.87 g/100 g), zinc (8.67-10.84 mg/d) and vitamin C (13.96-17.79 mg/100 g) but not calcium, iron and fat. The beta-carotene levels ranged from 74.8-346.6 µg/100 g and met between 3.1-14.5% of EAR for vitamin A.

A narrow, but significant variation was observed in the protein content of the weaning blends. Even though the new blends had lower protein content (compared to the control), all three blends contained higher amounts than the EAR for protein. This observation is significant because protein is a key component of weaning foods and weaning foods containing lower amounts of protein than the EAR are likely to result in protein energy malnutrition, which is a high contributor to infant mortality. The protein content of the blends in this study compares well with that of other products such as orange-fleshed sweet potato (OFSP) weaning blends [40] and maize-breadfruit pulp [41].

Adequate intake of micronutrients such as iron, zinc, calcium, vitamin A and vitamin C is important for ensuring optimal health, growth, and development of infants and young children [27]. It has also been recommended that for food fortified with one or more of either vitamins or minerals, the total quantity of each of these vitamins or minerals contained in a daily ration of the food should be at least 50% of the reference nutrient intake [28]. Zinc and vitamin C content of the RSM met this recommendation. However, β-Carotene which is a carotenoid with the highest provitamin A activity [28, 29] did not meet this requirement set by the Codex Alimentarius Commission (CAC). Mangoes are rich in β-Carotene, fiber and other phytochemicals. Mangoes also provide natural sweetness and taste in food. The formulated RSM products had a natural sweetness with significant amount of beta-carotene. However, these levels were not enough to meet 50% of the recommended intake of vitamin A. The RSM-0 (control) had insignificant amount of beta-carotene. This was expected since this formulation was not fortified with mangoes. The content of beta-carotene (retinol equivalent) increased with increasing percentage of dried mangoes in the formulation, ranging from 3.1-14.5% of the EAR for retinol. The iron content of all the formulations was lower than the requirement set by CAC. The RSM-10 had high levels of energy and protein and an appreciable amount of beta-carotene. It provides about 11% of the EAR for vitamin A and 36.6% of the EAR for iron. Based on these findings, RSM-10 may also have the potential to be adopted as weaning formulae in Ghana.

The moisture content of the RSM products was higher than the maximum level (<5%) recommended by the CAC standard for infant formula [28]. This could be a result of the high sugar content of the mangoes making the formulated product slightly hygroscopic. Lower moisture content gives shelf stability, as moisture could lead to product spoilage due to oxidation reactions [30]. This observation means the RSM products when commercially produced must be stored in packages with very good moisture-barrier packaging materials.

The pasting properties and colour were also determined for the newly formulated products. Pasting characteristics are among the most important parameters used to ascertain the suitability of flours and starches in food products. They have been used to predict the quality of some end-use products such as rice noodles and cooked rice [31, 32]. The weaning formulae showed marked differences in onset of gelatinization. Lowest gelatinization temperature (79.6°C) was observed in RSM-0, which obviously cooked faster compared to the others. The RSM-15 had pasting temperature and time which were quite related to that of the three remaining formulae. Peak viscosities of the formulated products were lower compared to the control formula (RSM-0). Among the three newly formulated blends, RSM-10 had the highest peak viscosity (74.0 BU) while RSM-15 had the least (64.0 BU). The highest final viscosity of 107 BU was recorded in RSM-10, and this was followed by RSM-5 with 104 BU. The RSM-10 had the highest setback viscosity of nearly 54 BU while RSM-15 recorded the lowest value of 25 BU. The extent of paste breakdown was highest in RSM-0 (10 BU) signifying a lower holding strength compared to the new formulations. Formula RSM-15 recorded the lowest extent of gel breakdown (5 BU) when exposed to constant shearing forces during cooking. This might be due to the presence of the high content of mango in the RSM-15 formulation which might have interacted with the starch to give the low breakdown. The RSM-5 and RSM-10 exhibited similarities in pasting properties and were closely related to the control formula. These formulations are, therefore, expected to behave in like manner when cooked.

Sensory attributes such as taste, texture, after-taste and mouth feel are important sensory attributes that determine products acceptability especially by an infant. The RSM-5 was the most preferred porridge in terms of taste, after-taste, mouth feel and overall acceptability (Table 6). Its limiting sensory attributes were taste and after-taste. Panelists were of the view that RSM-15 had an appealing appearance (Table 5) but a sour after taste. This sour aftertaste may have affected the taste and resulted in its dislike by panelists. The higher the percentage of semi-ripped dried mangoes in the formulation the more astringent the product. This observation was, however, in contradiction with studies by Neeraj *et al.* who developed mango flavored instant porridge and found that among all the fortification levels, 30% mango pulp fortification level was the best [33]. This finding could be due to the fact that the mango pulp used was from ripe mangoes. Studies have also shown a progressive loss of astringency which is associated with loss in total phenolic content [16]. Ripe mangoes with less phenolic compounds are non-astringent even though this may be influenced by varietal differences [16]. The sour aftertaste in RSM-15 formulation could be due to the high percentage semi-ripe mangoes. These may be more acidic and contain high levels of phenolic compounds, hence their higher astringency as compared to fully ripe mango pulp.

Aroma gives the nature of odor molecules and volatilized compounds in food. Aroma is an important sensory attribute in formulating infant food. Studies show that the detection of aromas is highly specific. Each aroma molecule activates a specific receptor on a particular membrane cell of the nasal mucosa. When an aroma molecule binds to a receptor, it sets off a sequence of events involving special signal proteins (G proteins), which control the opening or closing of channels in the cell membrane [34]. As such, food may be liked or disliked based on the aroma even without tasting. In this study, aroma was the only sensory attribute that showed significant differences among all four formulations (Table 6) with RSM-15 indicating the least acceptable aroma of 6.9 (like slightly) and RSM-5, with the most preferred aroma, was rated "like moderately" (7.54±1.23).

Reports have shown that protein sub-unit has increased number of hydrophilic groups, which are the primary sites of water binding and hence better consistency [35]. In this study, there was high rating of consistency (Table 4) with no significant differences ($p>0.05$) in the observed scores. This could be due to the fact that all the porridges had

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the same protein content. The high rating of consistency could be ascribed to the protein content of the products.

The mean acceptability scores of all newly formulated products remained high (like moderately). There were no significant differences ($p>0.05$) observed among the overall acceptability scores of the newly formulated rice-mango products. This indicates that all the formulations could be promoted for use at house-hold levels. Even though there were no significant differences seen among the acceptability scores, the most preferred option, based on most sensory attributes and comments from panelist, was RSM-5 with only 5% dried mango. Based on the sensory outcome alone, RSM-5 could be a potential product that may be recommended and adopted for use by Ghanaian households. This may be different when both the sensory attributes and the nutritional contents of interest are considered.

Colour of flour affects acceptability of products made from it and also indicates changes in quality due to processing and storage [36]. The Rice-Soy Mango formulations (RSM-5, RSM-10 and RSM-15) were all lighter than RSM-0, albeit not significant. The hue angle ranged between 101.43 and 102.57 for the flour blends (Table 7) and was significantly different from one flour blend to another. This range of values, together with the L index, suggests that the flour blends were yellowish and light. Increasing the content of mango resulted in the flour blend becoming more yellow, since those blends had hue closer to 90 (perfect yellow). The reason for this observation is ascribed to the gradual increase in proportion of mango, which must have contributed to more yellowness. The colour difference between RSM-0 and the mango-containing blends perceptibly increased when a lot more mango was added and is seen to range from 4.29 for RSM-5 to 8.62 for RSM-15 (Table 8). Colour of porridge from blends also followed a somewhat similar trend as the flour blends. Specifically, porridge containing high amounts of mango was darker than those with low amounts and the one without any mango (RSM-0). Hue of the porridge was lower and closer to 90 than the flours as mango proportion increased. This darkening may have been caused by browning and caramelization reactions which must have occurred during cooking. Again, the colour difference between RSM-0 and porridge from the other flour blends widened when more mango was added.

CONCLUSION

These newly formulated products were found to be rich in energy, protein, carbohydrates, calcium, zinc and vitamin C levels with about 3.1-14.5% vitamin A and 33.6-36.6% iron contents. This shows that the newly formulated products were adequate in both macro and micronutrients that can help solve the problem of protein-energy as well as micronutrient malnutrition observed in older infants and young children in Ghana. Increased mango content resulted in the flour blend becoming more yellow and attractive in colour. The sensory quality of the Rice-Soy Mango porridge was acceptable. Based on both nutritional and sensory qualities, RSM-10 had the highest potential of being adopted and promoted in Ghanaian households for older infants and children.

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Table 1: Composition of weaning blends formulated from broken rice, soybeans and dried mangoes

Blends	Broken Rice fraction (%w/w)	Soybeans (%w/w)	Dried Mangoes (%w/w)
RSM-0	75	25	0
RSM-5	70	25	5
RSM-10	65	25	10
RSM-15	60	25	15

RSM-Rice-Soy Mango

Table 2: Characteristics of the formulated Rice-Soy Mango Porridge as perceived by the trained panelist

Product	Overall Degree of Liking	Product Characteristics
RSM-0	Like moderately	Off-white flour which when reconstituted and cooked gives an off-white porridge.
RSM-5	Like extremely	Pale-cream flour which when reconstituted becomes a creamy porridge.
RSM-10	Like very much	Creamy flour which when reconstituted becomes a yellowish cream porridge.
RSM-15	Like moderately	Yellowish Cream flour which when reconstituted becomes a yellowish porridge.

RSM-0 – Rice 75%: Soybean 25%: Mango 0; RSM-5 – Rice 70%: Soybean 20%: Mango 5%; RSM-10 – Rice 65%: Soybean 25%: Mango 10% and RSM-15 – Rice 60%: Soybean 25%: Mango 15%

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Table 3: Proximate Composition, Mineral and β-Carotene Content of Formulated Rice-Soy Mango Blends[1,2,3]

Nutrient	RSM-0	RSM-5	RSM-10	RSM-15	EAR (7 -12 mo)
Energy (Kcal/100 g)	403.25 ± 1.04[a]	393.71± 2.32[b]	395.66± 1.46[b]	394.20± 0.01[b]	400
Carbohydrate (g/100 g)	68.44 ± 0.18[a]	72.67 ± 0.03[b]	71.27 ± 0.32[c]	73.87± 1.04[a]	95 g/d
Fat (g/100 g)	7.62 ± 0.19[a]	6.45 ± 0.09[b]	6.38± 0.15[a]	6.22 ± 0.04[b]	30 g/d
Protein (g/100 g)	15.24 ± 0.35[a]	11.25± 0.35[b]	13.3± 0.42[c]	10.7± 0.71[d]	9.6 g/d
Ash (g/100g)	1.87± 0.02[b]	1.68± 0.03[b]	1.78± 0.09[a,b]	1.81± 0.01[a,b]	< 3 %
Moisture (g/100 g)	6.83± 0.04[a]	7.95± 0.49[b,a]	7.28± 0.08[b,a]	7.420.04[b,a]	<5 %
Vitamin C (mg/100g)	17.79 ± 0.89[a]	16.63 ± 0.40[a]	13.96 ± 0.30[b]	15.32 ± 0.01[c,a]	25 mg/d
Iron (mg/100 g)	3.99± 0.06[a]	4.94± 0.03[a]	4.24± 0.10[a]	4.04± 0.77[a]	11.6 mg/d
Zinc (mg/100 g)	8.67± 0.06[a]	9.79± 0.06[a]	10.84± 0.11[a]	8.92± 0.64[a]	6.9 mg/d
Calcium (mg/100 g)	111.7± 0.06[a]	96.26± 0.06[a]	87.20± 0.06[a]	93.97± 0.06[a]	417 mg/d
β-Carotene (μg/100 g)	NS	74.8[a]	264.60[a]	346.60[a]	-
RE (μg/ 100 g)	NS	12.47[a]	44.10[b]	57.80[c]	400

RSM-0 – Rice 75%: Soybean 25%: Mango 0; RSM-5 – Rice 70%: Soybean 20%: Mango 5%; RSM-10 – Rice 65%: Soybean 25%: Mango 10% and RSM-15 – Rice 60%: Soybean 25%: Mango 15%
Values are means of triplicate determination ± standard deviation
EAR- Estimated Average Requirement
RE- Retinol equivalent
NS-Not significant
[1] WHO/FAO, 20 06 Dietary Reference Intake Recommendations [37].
[2] Codex 1991 [38].
[3] WHO 1998 [39].
Means, on the same row, bearing different superscripts show significant differences (p<0.05).

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Table 4: Pasting Properties of the Formulated Rice-Soy Mango Flour Blends

Blend	PT	PV	V-95	FV	BD	SB
RSM-0	79.6±1.3[a]	75.5±6.4[a]	65.0±2.8[ab]	106.0±4.2[a]	10.0±4.2[a]	52.5±6.4[a]
RSM-5	82.0±0.1[a]	72.5±4.9[a]	65.0±2.82[ab]	105.5±10.6[a]	7.0±1.4[a]	51.0 ±11.3[a]
RSM-10	82.5±0.1[b]	74.0±1.4[a]	119.0±7.1[b]	107.5±7.8[a]	7.5±0.7[a]	53.5±6.4[a]
RSM-15	81.1±0.2[ab]	64.0±1.4[a]	59.0±1.4[a]	76.0±0.0[b]	5.0±0.0[a]	25.0±1.4[b]

RSM-0 – Rice 75%: Soybean 25%: Mango 0; RSM-5 – Rice 70%: Soybean 20%: Mango 5%; RSM-10 – Rice 65%: Soybean 25%: Mango 10% and RSM-15 – Rice 60%: Soybean 25% : Mango 15%.
Means bearing different superscripts along a row are significantly different ($p \leq 0.05$). PT=Pasting temperature, PV=Peak viscosity, V-95=Viscosity at 95 °C, FV=Final viscosity, BD=Breakdown, SB=Setback

Table 5: Acceptability and Limiting Sensory Attributes of the Formulated Rice-Soy Mango Porridge

Product	Acceptability Score	Limiting Sensory Factor (s)	Comments
RSM-0	7.5 ± 1.0	Taste	Nice aroma but taste could be improved
RSM-5	7.5 ± 1.2	None	Perfect and excellent Porridge with milky after-taste. Nice taste and aroma
RSM-10	7.5 ± 0.9	After-taste	Even consistency with good mouth feel but slightly sour after-taste
RSM-15	7.0 ± 1.3	Taste and After-taste	Appealing appearance with sour after-taste

RSM-0 – Rice 75%: Soybean 25%: Mango 0; RSM-5 – Rice 70%: Soybean 20%: Mango 5%; RSM-10 – Rice 65%: Soybean 25%: Mango 10% and RSM-15 – Rice 60%: Soybean 25%: Mango 15%. Hedonic scale; 9 – Like extremely, 8 – like very much, 7 – like moderately, 6 – like slightly, 5 – neither like nor dislike, 4 – dislike slightly, 3 – dislike moderately, 2 – dislike very much, 1 – dislike extremely

Table 6: Mean scores for sensory attributes of the formulated Rice-Soy Mango Porridge

Attribute	RSM-0	RSM-5	RSM-10	RSM-15
Appearance	7.90 ± 0.71[a]	7.78 ± 1.06[a]	7.96 ± 0.99[a]	7.72 ± 1.01[a]
Colour	7.82 ± 0.75[a]	7.80 ± 0.99[a]	7.78 ± 0.93[a]	7.66 ± 0.98[a]
Consistency	7.76 ± 0.94[a]	7.70 ± 1.17[a]	7.62 ± 1.03[a]	7.62 ± 0.90[a]
Aroma	7.70 ± 1.02[a]	7.68 ± 1.17[a]	7.46 ± 1.01[b]	6.90 ± 1.53[c]
Taste	7.50 ± 1.07[a]	7.56 ± 1.13[a]	7.46 ± 1.13[a]	6.88 ± 1.41[b]
After taste	7.36 ± 1.10[a]	7.42 ± 1.19[a]	7.36 ± 0.99[a]	6.78 ± 1.40[a]
Mouth feel	7.30 ± 1.22[a]	7.62 ± 1.01[a]	7.52 ± 0.95[a]	7.18 ± 1.34[a]
*Willingness to Buy (%)	42(84)	43(86)	45(90)	37(74)

Means within a row followed by different superscripts are significantly different ($p<0.05$). *Indicates number of positive responses and the percentage of these responses are indicated in parenthesis. RSM-0 – Rice 75%: Soybean 25%: Mango 0; RSM-5 – Rice 70%: Soybean 20%: Mango 5%; RSM-10 – Rice 65%: Soybean 25%: Mango 10% and RSM-15 – Rice 60%: Soybean 25%: Mango 15%

Table 7: Colour of the Rice- Soy Mango Flour blends

Product	L	Hue angle (°)	ΔE
RSM-0	85.47±0.09[b]	102.57±0.08[a]	-
RSM-1	85.64±0.10[a]	102.66±0.09[a]	4.29±0.06[c]
RSM-2	85.73±0.02[a]	101.50±0.02[b]	7.02±0.04[b]
RSM-3	85.52±0.01[b]	101.43±0.01[c]	8.62±0.07[a]

L (Lightness or darkness), H (Hue angle), ΔE (Colour difference). Within a column, means with different superscripts are significantly different ($p<0.05$). RSM-0 – Rice 75%: Soybean 25%: Mango 0; RSM-5 – Rice 70%: Soybean 20%: Mango 5%; RSM-10 – Rice 65%: Soybean 25%: Mango 10% and RSM-15 – Rice 60%: Soybean 25%: Mango 15%

Table 8: Colour of the Rice-Soy Mango Porridge

Product	L	H	ΔE
RSM-0	71.37±0.25[a]	99.75±0.15[a]	-
RSM-1	70.57±0.12[b]	99.08±0.05[b]	3.02±0.12[c]
RSM-2	68.37±0.21[c]	97.87±0.09[c]	5.52±0.15[b]
RSM-3	66.28±0.15[d]	98.08±0.01[d]	6.53±0.12[a]

L (Lightness or darkness), H (Hue angle), ΔE (Colour difference). Within a column, means with different superscripts are significantly different ($p<0.05$). RSM-0 – Rice 75%: Soybean 25%: Mango 0; RSM-5 – Rice 70%: Soybean 20%: Mango 5%; RSM-10 – Rice 65%: Soybean 25%: Mango 10% and RSM-15 – Rice 60%: Soybean 25%: Mango 15%

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