

Complementary Foods from Rice and Six Other Ghanaian Food Ingredients Provide Sufficient Macro and Micronutrients for Infants 6-12 Mo of Age

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Abstract: Food base approach is considered to be a more viable and sustainable method of addressing micronutrient deficiencies in developing countries. A study to develop suitable micronutrient-rich complementary infant foods was carried out and characterized using rice (*Oryza sativa*, var. Togo Marshal) and six other Ghanaian food ingredients; soybean (*Glycine Max* var. Afayak), cowpea (*Vigna unguiculata*, var. Bengpla), mango (*Mangifera indica*, var. Kent), red palm (*Elaeis guineensis*, var. Dura) oil, groundnut (*Arachis hypogea*, var. Otuhia) and eggs. The complementary foods were initially developed from six blends, LR-1 (70% rice, 20% soybean, 5% groundnut, 5% dried mango), LR-2 (70% rice, 20% soybean, 5% groundnut, 5% egg yolk), LR-3 (70% rice, 20% soybean, 5% cowpea, 5% dried mango), LR-4 (65% rice, 25% soybean, 5% palm oil, 5% egg yolk), LR-5 (70% rice, 20% cowpea, 5% groundnut, 5% egg yolk), LR-6 (70% rice, 25% soybean, 5% dried mango). Sensory evaluation of these initial blends was conducted and the three most preferred blends were selected for further acceptability studies as well as the nutritional analyses using standard methods. The most desirable product based on sensory attributes was the formulation containing mango flour and soybeans (LR-6) followed by formulation containing soybean, groundnut and mango (LR-1). However there were no significant differences ($p = 0.05$) observed among the overall acceptability of the three best formulated products (LR-6, LR-1, LR-4). LR-4 had the highest amount of energy (427.6Kcal/100g), protein (15.82g/100g), fat (12.2g/100g), beta-carotene (5106.7 $\mu\text{g}/100\text{g}$) and iron (6.6mg/100g). LR-6 came out as the most preferred weaning food based on sensory evaluation. This study revealed the potential of using local ingredients including rice to produce micronutrient-rich complementary infant foods in developing countries. This will be of tremendous help to the less endowed households where the problem of infant malnutrition is most rife.

Keywords: Infant Complementary Foods, Ghanaian Local Foods, Vitamin A, Iron, Micronutrient

1. Introduction

Micronutrient deficiencies remain a challenge around the world, especially in developing countries. Food base approach has been shown to be a more viable and sustainable method to address micronutrient deficiencies [1, 2, 3, 4] In many developing countries, the problem of nutrient

deficiencies is partly due to the untapped potential of local food [5]. Locally available food ingredients such as rice, soybean, cowpea, groundnuts, palm oil, mangoes and egg yolk are rich in specific micronutrients important for infant growth and development.

Rice commonly grown in Ghana is a very rich carbohydrate source with high proportions in bran, a rich source of antioxidants [6]. Soybean is high in protein and fat.

Egg is rich in protein, amino-acid, iron and Vitamin A and while mango is rich in dietary fibre, Vitamin E, beta-carotene as well as essential minerals such as calcium, potassium and phosphorus [7, 8, 9, 10, 11, 12, 13]. Red palm oil is a rich source of beta-carotene which can subsequently be converted to vitamin A by the human body. It is also culturally acceptable and used in the preparation of various traditional foods. It is a rich source of antioxidants which acts as a buffer against free radicals. Food products with red palm oil such as biscuits have shown improvement in the vitamin A status after consumption [14]. These food ingredients when combined in right proportions in complementary foods may increase the nutrient contents of such infant foods and thus help solve the problem of micronutrient deficiencies commonly observed among infants. In most developing countries, these food ingredients are cultivated and used mainly in the preparation of traditional staple food by the rural dwellers. Their potential in diversified food product developments and alternative food preparations has not been fully exploited. Given their rich micronutrient sources, they are therefore good candidates for food base programmes aimed at addressing poor nutrition in infants in developing countries. This study therefore aimed at developing complementary foods from soybean, cowpea, groundnuts, palm oil, mango and egg yolk that can help solve the problem of micronutrient deficiencies in infant 6-12 mo of age in developing countries. We further determined the nutritional profile, sensory characteristics, and acceptability of the developed weaning food.

2. Materials and Methods

2.1. Raw Materials

The food ingredients used in this study were Rice (*Oryzae sativa*, var. Togo Marshall), soybean (*Glycine max* var. Afayak), cowpea (*Vigna unguiculata*, var. Bengpla) mango (*Mangifera indica* var. Kent), red palm (*Elaeis guineensis* var. Dura) oil, groundnut (*Arachis hypogea* var. Otuhia) and eggs. These were all obtained from an accredited supplier in Accra.

2.2. Preparation of Rice, Soybean, Cowpea and Mango Flour Samples

The rice sample was cleaned and sorted to remove chaff and other foreign materials, milled into flour using a hammer mill (Christy and Norris Ltd., Surrey, UK) and sieved to obtain a

flour of uniform particle size (250 μ). For the soybean and cowpea flours, five hundred gram each raw material sample was blanched separately in 1 L of water for 30 min at 100°C, after the initial cleaning and sorting. The legumes were then cooled at room temperature of 28°C, spread thinly on stainless steel drying trays, and dried in a hot air oven at 60°C for 8 h, dehulled in a disc attrition mill (Hunt No. 2A Premier Mill, Hunt & Co., UK), winnowed and milled into flour of uniform particle size (250 μ) using the hammer mill. To obtain the mango flour sample, Kent mangoes, at Stage 4 ripeness with average 13⁰Brix [15], were first washed under running tap water, peeled and sliced into very thin pieces for easy drying and dried at 60°C for 18 h in an oven. The dried mangoes were added to the rice, milled together and then sieved in a 250 μ mesh for uniform particle sizes. Combinations that involved both mangoes and groundnuts in their desired quantities were added to the rice and all three ingredients were milled in the hammer mill before sieving to obtain a uniform particle size. The rice, soybean, cowpea and mango flours were all kept in airtight clear polypropylene bags in a refrigerator at 4°C until ready to use.

2.3. Preparation and Incorporation of Groundnut Flour, Egg and Palm Oil Samples

Prior to preparing the groundnut sample, care was taken to eliminate the possibility of mycotoxins using the CRSP procedure [16]. This involved sorting out the immature, shriveled, discolored and damaged kernels from the clean kernels and then roasting in an oven at 140°C for 30 min with intermittent stirring every 10 min. The roasted groundnuts was mixed with the rice flour and milled together in the hammer mill (at inclusion levels indicated in Table 1) into flour. The flour was then sieved through a 250 μ mesh to obtain a uniform particle size, packaged airtight in clear polypropylene bags and stored at in a refrigerator at 4°C. The egg yolk and palm oil samples were added into a small portion of flour through the rubbing-in method. A manual mixer was then used to thoroughly mix the desired quantity of flour to obtain a uniform combination. To obtain an extended shelf life, final flour combinations with egg and palm oil mix was slightly roasted under low temperature in the hot-air oven at 60°C for 20 minutes.

2.4. Blend Formulation

Different blend formulations (Table 1) used were based on the RDA of children below 5 years and the nutrient content of each ingredient [17].

Table 1. Composition of Complementary food formulations Used for the Study.

Formula	Component (%)						
	Rice flour	Soybean	Cowpea	G'nuts	Palm oil	Mango flour	Egg yolk
LR1	70	20	-	5	-	5	-
LR2	70	20	-	5	-	-	5
LR3	70	20	5	-	-	5	-
LR4	65	25	-	-	5	-	5
LR5	70	-	20	5	-	-	5
LR6	70	25	-	-	-	5	-

G'nuts: Groundnuts

2.5. Preparation of Porridge

One hundred gram of each flour formula was mixed in 880 ml of water and stirred to obtain a slurry. A pinch of salt (less than 1 g) and 20 g of sugar were added and the slurry boiled for 6-8 min. Porridge was served in 30 mL polypropylene tumblers while still lukewarm.

2.6. Sensory Evaluation

The sensory attributes of appearance, colour, aroma, taste, texture, mouth feel, aftertaste and overall acceptability of all six products were initially evaluated using a nine-point hedonic scale ranging from 1 (dislike extremely) to 9 (like extremely), by a panel comprising 10 mothers whose children were aged between 6 and 59 mo. These mothers were specially recruited and trained as expert panelists, after they had given their consent to take part in the study. Panelists were provided with an unsalted cracker and water to refresh their palate before evaluating successive samples.

These mothers were further used to refine the developed products to help select the best three complementary food formulae. The refining involved asking the mothers to rate their acceptability of the products and make comments and suggestions on what could be done to improve on product. For example, if almost all the mothers said a particular product was too beany, we went ahead to reduce the percentage of cowpea beans etc. Through this, the products were improved based on their comments and sent back to them for another re-evaluation. This was done about three times in order to get an improved product for each combination. They helped select the three best products that were used for the subsequent acceptability tests. All sensory evaluations were carried out in a facility conforming to ISO 8589.

2.7. Consumer Acceptability

The three selected formulae (LR-1, LR-4 and LR-6) from the sensory evaluation were used for the consumer preference testing, which involved another set of sixty mothers, whose children aged between 6 and 59 mo, as panelists. These panelists were recruited from 5 child-care/weighing centers in the La Nkwantanang-Madina District, Accra. The mothers consented to be part of the study were after the whole study

was fully explained to them. These mothers assessed the colour, appearance, taste, aroma, mouth feel, constituency and overall acceptability of porridge samples prepared from the 3 newly developed formulae, using the 9-point hedonic scale with 1 representing “dislike very much” and 9 representing “like very much.”

2.8. Nutritional Composition of Weaning Blends

Proximate composition, mineral and vitamin A were determined for the best 3 complementary food formulae using standard procedures [18]. Carbohydrate was calculated by difference. Energy values were determined using Atwater factors 3.47, 8.37 and 4.00 for protein, fat and carbohydrates respectively [19].

2.9. Statistical Analysis

The sensory evaluation data was analyzed using a one-way analysis of variance (ANOVA) with the different formulations as the main factor. A 0.05% level of significance was adopted to establish differences between attributes of the different preparations. Significantly different means were separated using Duncan's Multiple Range Test (SPSS 17.0.1).

3. Results

3.1. Trained Panel Sensory Evaluation for 6-Porridges Made from Complementary Food Formulae

Table 2 presents the results of sensory assessment of porridge prepared from all 6 initial complementary formulations. Colour, aroma and taste of the blends showed significant differences. LR-1 was best in aroma and mouth feel, while LR-2 was best for consistency. LR-4 was best in appearance, although it was not significantly different ($p>0.05$) from the other formulations. LR-6 was best in colour and taste and showed significant differences ($p<0.05$) when compared with LR-2 and LR-4 in terms of colour. LR-6 which contained mango was also significantly higher in taste compared with LR-2, LR-3 and LR-5. Scores for aroma varied widely and ranged between 2.3 and 8.2. LR-5 and LR-3 which contained cowpea was the least preferred in terms of aroma and taste.

Table 2. Sensory attributes of the six initial complementary food formulations.

Sensory Attribute	Formulation					
	LR-1	LR-2	LR-3	LR-4	LR-5	LR-6
Appearance	8.0±1.0 ^a	7.8±1.2 ^a	7.6±0.8 ^a	8.5±0.3 ^a	7.8±0.8 ^a	7.8±1.0 ^a
Colour	7.3±0.8 ^{ab}	5.1±1.1 ^a	5.2±0.9 ^a	8.6±0.4 ^b	7.8±1.0 ^b	7.8±0.8 ^b
Aroma	8.2±0.6 ^b	4.1±2.1 ^a	3.1±1.0 ^a	7.9±0.9 ^b	2.3±1.5 ^a	7.8±0.6 ^b
Taste	7.8±0.9 ^b	5.3±0.8 ^a	4.2±1.1 ^a	7.8±0.6 ^b	3.3±1.4 ^a	8.0±0.6 ^b
Consistency	7.1±1.2 ^a	7.8±1.4 ^a	6.4±1.0 ^a	7.4±1.2 ^a	6.3±1.1 ^a	7.1±0.8 ^a
Mouth-feel	8.1±0.6 ^a	7.4±1.0 ^a	7.2±0.9 ^a	6.3±1.4 ^a	7.2±0.4 ^a	7.9±1.0 ^a

Means in the same row with different superscripts are significantly different ($p<0.05$)

Acceptability and limiting sensory factors for the initial six complementary food formulations are given in Table 3. Two

out of three products, which had mango flour were liked “very much” and “extremely” and the remaining one, which

contained cowpea, was moderately preferred by trained panelist. The addition of mango flour to the formulations with soybeans gave it an attractive colour. This therefore enhanced the overall acceptability of the formulations containing mango flour. LR-1, LR-4 and LR-6 had no limiting sensory attribute. LR-2 was limited in aroma while

LR-3 and LR-5 were limited in both taste and aroma. LR-6 was ranked as the most preferred, LR-1 and LR-4, very much preferred, LR-3 and LR-2 moderately preferred and LR-5 slightly preferred. The three most preferred products (LR-1, LR-4, LR-6), based on overall acceptability, were used for the final consumer acceptability testing.

Table 3. Acceptability and Limiting Sensory Factors of the six complementary food formulations.

Formula	Acceptability	Inference	Limiting Sensory attributes (s)
LR-1	8.3±0.6 ^b	Very much	None
LR-2	6.6±1.0 ^a	Moderately	Aroma
LR-3	6.8±0.6 ^a	Moderately	Taste and Aroma
LR-4	8.4±0.4 ^b	Very much	None
LR-5	6.3±1.3 ^a	Slightly	Taste and Aroma
LR-6	8.6±0.4 ^b	Extremely	None

Means with different superscripts are significantly different (p<0.05)

3.2. Consumer Acceptability for the Three Preferred Complementary Food Formulations

Figure 1 presents a pictorial summary of results from consumer acceptability studies on porridge prepared from the three most preferred formulae, namely LR-1, LR-4 and LR-6.

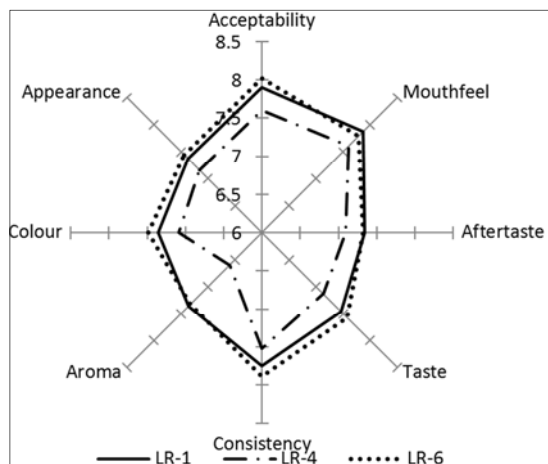


Figure 1. Profile of sensory attributes from consumer acceptability test of the three preferred complementary food formulations.

Porridge from LR-1 and LR-6 blends was rated similarly in all the attributes and therefore they present an identical profile. LR-4 on the other hand shows a profile which is somewhat comparable to the earlier blends in other attributes but dips in its score for aroma, which changes its outline. Appearance, colour and taste in all the blends, generally retained a score of about 7, and consistency and mouth-feel, 7.5 or greater. These scores interpret as “like moderately” and “like very much” on the 9-point hedonic scale. For these

sets of attributes, no significant differences (p>0.05) were recorded among the three blends. In the case of aroma, however, the blends were markedly different (p<0.05), with LR-4 being rated the lowest among the three.

Out of the sixty caregivers who were interviewed, 91.8% were willing to buy both LR-6 and LR-1 whereas 83.6% were willing to buy LR-4. Chi squared test (Table 4) indicated no significant differences (p>0.05) among these responses.

Table 4. Product acceptability, comments and willingness-to-buy.

Product	Acceptability	Inference	Willingness to Buy		
			Frequency	χ^2	p-value
LR-1	7.9 ± 1.3 ^a	Very much	56	2.807	0.246
LR-4	7.6 ± 1.3 ^a	Very much	51		
LR-6	8.0 ± 1.2 ^a	Very much	56		

3.3. Proximate Composition, Mineral and Vitamin Content of the Three Preferred Complementary Food Formulations

Proximate composition, beta-carotene levels and mineral content of the three preferred complementary foods are shown in Table 5. Considerable differences (p<0.05) were observed between the 3 formulae for all the nutrients apart from ash. Moisture content ranged between 6.7-9.7% for the flour blends.

LR-1 had a significantly high content of calcium. LR-4 was significantly high in energy, protein, fat, iron and beta-carotene, whilst LR-6 had the highest carbohydrate and zinc. LR-1 had negligible amounts of beta-carotene. LR-6, which contained the same quantity of mango, recorded a small amount of beta-carotene content. LR-4 provides a much higher nutrient profile than the other two formulae.

Table 5. Proximate Composition, Mineral and Vitamin content of the 3 preferred complementary food formulations.

Nutrient Composition	LR-1	LR-4	LR-6	EAR (7-12 mo)*
Energy (Kcal/100g)	393.99±0.89 ^b	427.77±0.11 ^c	383.80±0.16 ^a	400 kcal
Moisture (%)	9.34±0.01 ^b	6.70±0.01 ^a	9.70±0.00 ^c	3-8 %
Protein (g/100g)	14.83±0.12 ^a	15.82±0.17 ^b	15.52±0.08 ^b	9.6 g
Fat(g/100g)	7.50±0.16 ^a	12.20±0.78 ^b	5.80±0.05 ^a	30 g/d
Ash (g/100g)	1.50±0.04 ^a	1.65±0.06 ^a	1.52±0.02 ^a	<3 %
Carbohydrate (g/100g)	66.87±0.26 ^b	63.63±0.31 ^a	67.46±0.15 ^b	95 g/d
Iron (mg/100g)	3.61±0.40 ^a	6.65±0.24 ^b	4.00±0.13 ^a	11.6mg/d

Nutrient Composition	LR-1	LR-4	LR-6	EAR (7-12 mo)*
Zinc (mg/100g)	0.90±0.01 ^a	1.83±0.13 ^b	3.44±0.10 ^c	6.9 mg/d
Calcium (mg/100g)	31.26±2.21 ^b	22.94±0.01 ^a	23.33±0.01 ^a	417 mg/d
Vitamin C (mg/100g)	1.12±0.00 ^b	1.12±0.00 ^b	0.90±0.01 ^a	25 mg/d
β-carotene (μg/100g)	NS [†]	5106.7 ^b	334.0 ^a	-
RE (μg/100g)	NS	851.12 ^b	55.67 ^a	400 μg/d

Values are means of triplicate determination ± standard deviation. Means within a row with different superscripts are significantly different ($p < 0.05$). [†] Not significant. * EAR- Estimated Average Requirements [17].

4. Discussion

This research aimed at using locally available food ingredients rich in micronutrients, in formulating complementary food for infants' 6-12 mo of age. This would contribute to solving both protein energy malnutrition and micronutrient deficiencies (especially iron and vitamin A deficiencies) among infants in developing countries. In this study local rice, soybean, cowpea, groundnuts, palm oil, mango and egg yolk were used to formulate weaning porridge.

Sensory evaluation showed that blends containing mango were the best in terms of colour, aroma and taste. Appearance, which includes colour, is a primary attribute which attracts consumer attention and therefore influences acceptance and purchase of food products [20]. Appearance of porridge from all six complementary food formulae was either liked very much or liked extremely. Scores for colour, on the other hand were significantly different ($p < 0.05$) and ranged between 5.1 and 8.6, the least rating corresponding to LR-2 and LR-3. LR-6 and LR-4 were rated higher for their colour compared to LR-5 and LR-1. The high rating for LR-6 could be due to addition of mango which gave the porridge a creamy yellowish colour as such was pleasant and attractive to panelist.

Aroma of porridge prepared from the blends must have been influenced by either cowpea or groundnuts. LR-5 and LR-3, which contained cowpea, received the lowest rating, perhaps as a result of the beany flavor which was more intense in the cowpea. Cowpea is known for its beany flavor which is usually not acceptable by some consumers [21]. As a result, aroma was a limiting sensory attribute for these two weaning formulae (Table 3). Aroma may lead to the rejection of complementary food by infants if it turns out to be unattractive. Acceptance of food by infants has been shown to correlate with its taste, with sweetness being the most preferred [22, 23]. Taste of porridge from the 6 initial blends ranged from "dislike slightly" to "like very much" and was in the order LR-6, LR-4, LR-1 > LR-2 > LR-3 > LR-5. Although some similarities in taste occurred among some porridge samples, considerable differences ($p < 0.05$) generally existed among the samples. Apart from LR-3 (which also contained cowpea), porridge from blends containing mango flour (LR-1 and LR-6) showed promising taste and were both liked very much by panelists.

Consistency and mouth-feel are considered important in semi-solid foods. In complementary foods, this may influence the extent of consumption, since children of this

age may only swallow and not be able to chew on particles. This attribute directly influences preference among children [24], and semi-liquid porridge is the most appropriate. Rating for these two attributes were within the acceptable range, since all the blends received a score of 6 (like slightly) or higher. None of the products were significantly different ($p > 0.05$) in terms of consistency and mouth-feel, an indication that none of the ingredients adversely affected these attributes.

Acceptability (Table 3) ranged from 6.3 (like slightly) to 8.6 (like extremely) for porridge made from the 6 complementary food formulae. Even though preference for the products differed markedly ($p < 0.05$), some similarities in acceptability among LR-6, LR-4 and LR-1 were observed. LR-3 and LR-5, which contained cowpea, had low acceptability scores because of the undesirable beany flavor which impacted on their aroma and taste. LR-6, LR-4 and LR-1 had no limiting sensory characteristics and were widely acceptable to the trained panel.

4.1. Consumer Acceptability

Overall acceptability for the three selected blends ranged between 7.6 and 8.2 for LR-4 and LR-6 respectively (Table 4). This range of acceptability rating translates into "like very much" on the 9-point hedonic scale. In general, the formulations with soybeans and mango flour with or without groundnut (LR-1 and LR-6) were scored a little higher than the formulation with soybean, palm oil and egg (LR-4). The low score for LR-4 may be attributed to the inclusion of palm oil and egg yolk in this blend which must have resulted in an aroma not quite familiar to the panelists. Regardless of the varying ratings, no significant difference ($p > 0.05$) was established for acceptability among porridge from the 3 weaning formulae, an indication that all three were liked to a similar extent. Mangoes have a sweet taste and pleasant aroma. This may account for the high acceptability for the mango based products.

4.2. Nutrient Composition of the Complementary Foods

Energy, protein and micronutrients such as iron, zinc, calcium, vitamin A and C are important for optimal growth, and development of infants and young children [25]. It is recommended that infant food should be well balanced to meet about 50% of the reference nutrient intake [26]. Considerable differences ($p < 0.05$) were observed between the three selected formulae for all the nutrients except ash. LR-4 had the highest amount of energy, protein, fat, beta-carotene and iron but was lowest in carbohydrates. This is

attributed to the palm oil and egg yolk in this formulation, which are both rich in fat and beta-carotene. Red palm oil is rich in beta-carotene which is a remarkable source of vitamin A [13]. It is also culturally acceptable and used in the preparation of various traditional foods. This helps prevent vitamin A deficiency among children as well as provide antioxidants which acts as a buffer against free radicals to prevent cardiovascular diseases [27, 28, 29, 30]. Several feeding trials incorporating red palm oil into diets at household level or into commercially manufactured products has shown improvement in beta-carotene content of food [11, 12, 13]. Consumption of red palm oil incorporated in a sweet snack or biscuits significantly improved plasma retinol concentrations in children with subclinical vitamin A deficiency [14]. Palm oil retains about 80% of its carotenoids after processing, and therefore makes a remarkable source of Vitamin A. In this study, LR-4 (which contained 5% of palm-oil) significantly improved the beta-carotene content of the formula above its EAR compared to the formulae without palm oil. Palm oil could therefore be used as a great potential to address the problem of vitamin A deficiency.

LR-4 was rich in proteins and iron. The high content of protein and iron in LR-4 could be due to egg yolk in the formulation. Egg yolk is a rich source of protein, amino acids and iron [9]. It is also one of the few naturally containing vitamin D [10]. The inclusion of these ingredients (palm oil and egg yolk) at 5% contributed to enhancing the protein, iron and vitamin A content of the weaning food. WHO recommends the inclusion of vegetable oil in infant formulae to serve as a carrier for fat soluble vitamins and also increase energy density [31].

LR-4 contained 5% less rice flour than the other formulae and this accounted for its significantly lower ($p < 0.05$) carbohydrate content. LR-1 had the highest content of calcium but had the lowest level of most of the nutrients. This blend contained insignificant amounts of β -carotene and retinol LR-6 generally had a nutritional composition that lay between that of LR1 and LR4. Nevertheless, its fat, carbohydrate and iron contents were comparable to those of LR-1. The relatively lower amounts of beta carotene and retinol in these two formulae (LR1 and LR-6) compared to LR-4 could be attributed to low amount of mango in these blends. Analysis of different types of mangoes showed a progressive increase in beta-carotene levels as fruit ripens [8]. Studies have also shown a higher serum retinol and beta-carotene levels after consumption of mangoes by children in Senegal [7]. Ripe mangoes are rich in beta-carotene and may help improve vitamin A status [32, 33].

The formulations offered appreciable amounts of macronutrients which satisfied at least half of their EARs. In the case of the micronutrients, however, only LR-4 and LR-6 contained enough zinc to meet more than half its EAR. Iron and vitamin C were generally lower in the weaning food blends, compared with their EARs. The β -carotene and retinol content presented by LR-4 exceed the EAR for these nutrients whereas LR-6 met about one-tenth of retinol and less than half of β -carotene.

Moisture content of the formulated complementary food flour ranged between 6.7-9.7%. This low moisture contents which implies low water activity will help maintain keeping qualities during storage [34]. High moisture levels are conducive for the growth of micro-organisms and also facilitate chemical reactions which cause deterioration in product quality [34]. Moisture is a critical factor since weaning formulae are usually prepared in large quantities and stored for use as an when it is needed.

5. Conclusion

The study has shown that food commodities such as rice, soybean, eggs, palm oil, and mangoes normally used as staples for adult have the potential being used as complementary food to improve both beta-carotene and iron contents for children. The sensory evaluation and acceptability studies conducted indicated that three different formulations, namely LR-1, LR-4 and LR-6 were widely acceptable. Nutrient content of these three blends were appreciable, particularly LR-4, whose energy, protein, fat, as well as vitamin A, iron content met more than half of the EAR. These complementary formulae may be a potential source of micronutrient that can help solve both macro and micro-nutrient malnutrition (especially vitamin A and iron) in Ghana and the developing world. The additional lesson from this study is that local ingredients should not be underestimated because they have the potential of addressing the problem of infant micronutrient deficiencies in the developing world.

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