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Quality Evaluation of Nine Instant Weaning Foods Formulated from Cereal, Legume, Tuber, Vegetable and Crayfish

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Abstract Poor weaning practice and malnutrition are still a public health problem in developing countries, Cameroon inclusive, since the commercial weaning foods may not be quite affordable. Nutritional, functional, microbial and sensory acceptability of Irish potatoes- and rice-base weaning foods were investigated. Three weaning Irish potato-base diets (A1, A2, A3) diets and six weaning rice-base diets (*B1, B2, B3, B4, B5 and B6*) each differing in the ratio of soybean, crayfish and carrots were formulated, fortified with sucrose and compared to reference weaning diet (phosphatine). The formulated diets were fed to weaning albino rats for four weeks and compared to a commercial diet as reference/control (Multi-cereal phosphatine). Results showed that the fat content of experimental diets ranged between 3.13±0.91 and 14.35±0.55. The carbohydrates range was 24.56% and 54.79% while the energetic value was comparable with that of phosphatine (396.91±24.08 and 371.74±21.14 kcal respectively for B4, and B5). Functional characteristics indicated good dispersibility, swelling index and density. *Diet B4, was very much comparable to phosphatine than all the other foods in most of the properties. Mineral contents particularly, Ca, Mg, Na, and Mn in all formulations were significantly higher (p>0.05) than in the commercial reference diet. Better growth responses of the organs, rats weights, the highest protein efficiency ratio and food efficiency ratio were shown in the rats fed formulated weaning diets than the commercial diet.*Trained sensory evaluation panellists generally scored the enriched flour porridge to be acceptable. These enriched flours have great potential as a weaning food in resource-poor and technologically under-developed countries. The results showed that the formulated Diets had the desired characteristics of a weaning food, hence could be used for alleviating protein energy malnutrition (PEM) in infant.

Keywords Malnutrition, Weaning food, Formulation, Fortification

1. Introduction

Scientifically, breast milk is the perfect food for the infant during the first six months of life [1]. Chronic malnutrition has been and still remains persistent problem for young children in sub-Saharan Africa [2]. The World Health Organisation (WHO) recommends exclusive breast feeding for the first six months of life with the addition of complementary feeds (which are known as complementary weaning foods) with continuous breast feeding until the age of about two years [3].

Human milk is the best food for babies and provides all the nutrients for about the first six months (26 weeks) of life. Moreover it contains nutrients that serve unique needs for human infants such as essential polyunsaturated fatty acid, certain milk proteins, iron and zinc in a readily absorbable form, human milk also contain immunological and bioactive substance [4]. Complementary feeding is the provision of foods or fluids to infants in addition to breast milk. Complementary foods can be subdivided into: Transitional foods that are complementary foods which specifically designed to meet particular nutritional or physiological needs of infants and family foods; that are complementary foods given to young children and are broadly the same as those consumed by the rest of the family [5].

Malnutrition remains a persistent problem for children in developing countries [6]. Initiation of complementary food too late or too early can lead to malnutrition. Complementary feeding time is the time when malnutrition starts in many infants contributing significantly to the high prevalence of malnutrition to children less than five years of age [7]. The

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nutritional value of complementary food should meet the nutrient requirement of rapidly growing children and the food should be diverse with appropriate texture and given in sufficient quantity [8]. Poor nutritional quality and inadequate quantity of complementary foods is reported to have negative impacts on the child. They affect growth [9, 10], hamper mental development [11]. and increase infant morbidity [12, 13] and mortality [14].

In developing countries, 70% of weaning foods are supplied by cereals which are relatively poor source of protein [15]. Formulating and development of nutritious weaning foods from locally and readily available raw materials have received a lot of attention in many developing countries [16]. Apart of protein and energy infants diet need calcium, iron and trace elements which can be obtained by combining local staples presently available in the country. Traditional infant foods made of cereals or tubers are known for their high bulkiness and concentrations of fiber and inhibitors anti-nutrients which reduce their nutritional benefits [17, 18]. Bulkiness, often associated with gelatinization of the starch during boiling is a key problem in cereal-based complementary foods [19]. Raw materials of most commercial complementary food are not locally available. Most of the commercial foods need to be mixed and some even need to be cooked before eating and some need processes that reduce nutrients which wastes time than ready to eat foods.

Since most commercially available weaning foods are expensive so not affordable by low income mothers, the problem of malnutrition in infants can be solved by introduction of nutritious complementary food. Ndop rice, crayfish, Irish potatoes, carrot, soya beans and table sugar used for diet formulation in this study, are locally produced in large quantities in Cameroon yet children still die of hunger.

The aim of this study therefore is to formulate, produce and evaluate ready to eat food (instant food) based on local raw ingredients and intended for mothers/caregivers to feed their children and/or buy the product at lower price thus reducing infant malnutrition in Cameroon.

2. Materials and Methods

2.1. Sample Collection, Processing and Formulation

2.1.1. Sample Collection

Irish potatoes, carrot, as well as soyabeans were all purchased from the local market in Muea, Buea, South West Region of Cameroon. Ndop rice was purchased at the local market in Ndop, North West Region of Cameroon. The wistar albino rats (21-25 days old) of both sexes weighing between 21 and 50 g were bought from the animal house of the Laboratory of biotechnology laboratory of the University of Buea, South West Region of Cameroon.

2.1.2. Sample Preparation and Processing

Processing of Carrot: Carrot was screened for rot, insects, and other defects. The carrot was then peeled to expose the flesh, then sliced and boiled for 15minutes. The diced pieces were transferred to a hot air oven set at 80°C for 7 hours.

Processing of Irish Potatoes: The Irish potatoes were washed to remove soil from the tubers. They were then peeled, boiled for 20 minutes and cut into small pieces. These were then dried in an oven at 80°C for two days.

Processing of Soybeans: Soybeans were sorted for stones, rot, and other physical defects. The beans without defects were cleaned, soaked for 3h, dehulled and boiled for 15 minutes, oven-dried at 80°C for 24hours and roasted under an open flame until golden brown for 30minutes.

Processing of Ndop Rice: 3kg of Ndop rice was checked for defects and was washed twice, then boiled for 30 minutes in about 5 liters of water that was added twice during the cooking process. The boiled rice was oven-dried for 2 days in a hot-air oven set at 100°C to avoid microbial contamination and fungal development.

Processing of Crayfish: Dry crayfish was sorted for stones and other unwanted particles and hard bones. All the dried samples were dry-milled, sieved with a 75micron aperture sieve in order to remove large particles so as to obtain smooth four which were all stored in zip-lock bags pending diet formulation and laboratory analyses (Figure 1).

2.1.3. Blend Formulation.

The blends were prepared or mixed from the individual flour ingredients in the percentages or proportions as shown in table 1.

2.2. Physicochemical Analysis

2.2.1. Proximate Analysis

The moisture, ash, fat, crude protein (% N x 6.25) and crude fibre of the samples were determined by the AOAC method [20]. Moisture was determined based on AOAC Method 934.01: Air Oven Method [20]. Crude protein was determined based on AOAC Method 960.52: Micro-Kjeldahl Method [20]. Fat was conducted based on AOAC Method 963.15: Soxhlet Extraction Method utilizing Hexane as solvent [20]. Crude fibre was determined by neutralisation method (Method 962.09) [20]. Ash content was determined based on AOAC Method 923.03: Dry Ashing Method [20]. Carbohydrate content was estimated by difference and caloric value was measured by calculation using the Atwater's conversion factors [21, 22]. Minerals were determined by Atomic Absorption Spectrophotometer, Hitachi Model 180-80, and Ion Chromatographic Analyzer ICA model IC 100 [20].

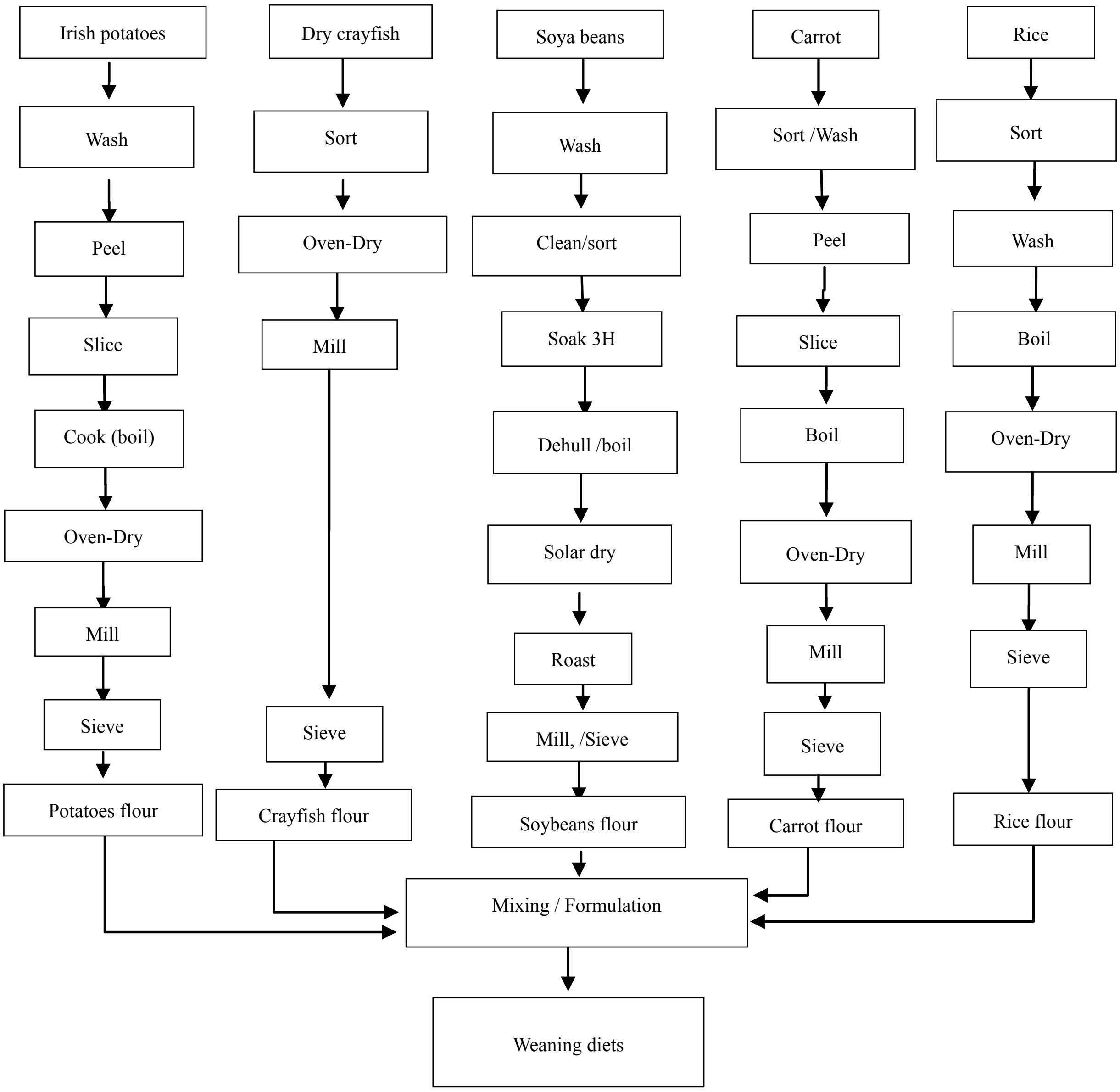

Figure 1. Flow chart on preparation of various composite flours

Table 1. Composition of Blends

Ingredients Blend	Rice flour (g/100g)	Soybean Flour (g/100g)	Crayfish meal (g/100g))	Carrot flour (g/100g)	Sugar (g/100g)	Irish potatoes (g/100g)
B1	70	10	10	5	5	/
B2	30	50	10	5	5	/
B3	65	15	10	5	5	/
B4	15	65	10	5	5	/
B5	40	40	10	5	5	/
B6	60	20	10	5	5	/
A1	/	10	10	5	5	70
A2	/	15	10	5	5	65
A3	/	20	10	5	5	60

2.2.2. Determination of Functional Properties

Water absorption capacity (WAC) and Oil Absorption Capacity (OAC) were determined using the method described by Cegla *et al.* [23] and Beuchat [24] respectively.

Bulk Density (BD) was determined using the modified method described by Wang and Kinsella [25].

Foaming Capacity (FC) was done According to Kinsella [26] Cherry and McWatters [27].

Swelling Index (SI) was done according to the method of Abbey & Ibeh [28].

Dispersibility: The Dispersibility of the blends was determined as described by Kulkarni et al. [29].

2.3. Rat Bioassay

Rats were divided into six (6) groups of 6, with five different composed diets and commercial formula (phosphatine), and five different blends were prepared and used for animal feeding experiments. Weanling six Wistar albino rats (21-23 days old) were randomly distributed into five groups, with 6 rats per group. The rats were housed individually in buckets with grill-covered tops and were kept under usual management conditions in conventional animal house of life sciences laboratory, University of Buea. The rats were acclimatized and then fed the formulated Blends and phosphatine reference diet for one month. Diet and water were supplied *ad libitum.* Weights of all rats were recorded at the beginning and at the end of the study.. At the end of the study, the rats were dissected and the weights of their kidneys, hearts and livers were taken. The protein quality of the diets was analysed using the Protein Efficiency Ratio (PER) and Food Efficiency Ratio (FER) calculated using the formula: PER = Weight gain by test group (g) / protein consumed (g) and FER = Gain in weight (g) / food consumed (g)

2.4. Microbial Analysis

The freshly prepared formulations were subjected to microbial analysis immediately after preparation. They were tested for bacteria, mould and yeast. Serial dilutions were made from 1g of each sample dissolved in 9ml of distilled water. Using the pour plate method, each diluent was plated out on a plate count agar bacteria count and malt extract for yeast and mould. The plates were incubated at 37°C for 48h for bacterial growth and at 27°C for 3days for yeasts and mould. Colonies developed after incubation was counted.

2.5. Preparation of Porridges and Sensory Analysis

Porridges were prepared from both the composite flours and phosphatine. 100 grams of each formulated diet were mixed with 400ml of boiled distilled water. 5 grams of granulated sugar for taste were added to the porridge. The samples were allowed to cool at room temperature (25 ±2°C). The porridges were kept separate in thermos flasks to maintain the serving temperature of 40°C. The formulated foods were evaluated alongside a commercial complementary food (Multi-cereal-Phosphatine).

Sensory evaluation of the porridges was conducted at the Life Science teaching Lab. Fifty Students, mothers and lecturer were randomly selected and trained. Each of the panelists was seated in an individual compartment with fluorescent lighting and free from distraction. The judges evaluated the samples for flavour, taste, colour, texture and overall acceptability using a nine point hedonic scale, where 9 was the highest score and 1 the lowest [30]. The degree to which a product was liked was expressed as like extremely (9 points), like very much (8 points), like moderately (7 points), like slightly (6 points), neither like nor dislike (5 points), dislike slightly (4 points), dislike moderately (3 points), dislike very much (2 points), and dislike extremely (1 point). The panelists were presented with 20ml coded sample. Each panelist was given five white plastic cups and teaspoons for use in the sensory test. Clean water was provided to the judges to rinse their mouth in-between testing of the sample to avoid carry over effect. Room temperature of 25 ± 2°C was maintained throughout the testing sessions.

2.6. Statistical Analysis

Data obtained from the study were analysed using means and standard variation for triplicate values. Analysis of variance was used to establish any significant difference between the blends and control and the differences were separated using Duncan's Multiple Range Test (DMRT) at a level considered to be significant at 5% level of significance ($p < 0.05$). Results were calculated and expressed as Mean ± Standard Deviation using the software Graphpad Insat 2000 version.

3. Results and Discussion

3.1. Proximate Analyses

3.1.1. Nutrient Content of Formulated Diets

Table 2 shows result of proximate composition of the formulated complementary foods. The crude protein, ash, crude fibre, fat, moisture (dry basis), carbohydrates and energy kcal/100g ranged from 18.30-42.38; 2.05-4.29; 3.48-7.37; 4.14-14.35; 4.14-8.25; 24.56-56.64 and 343.06-396.91 kcal/100g respectively. A1, A2, A3, B2 and B4, had lower ($p < 0.05$) moisture contents but which were significantly higher when compared to moisture content of phosphatine (1.05%). Moisture contents are within the recommended value [5-10%] except phosphatine (low moisture content 1.05%) probably due to the worry of prolonging or increasing the shelf life of that commercial product. Moisture content of food is an important index of their susceptibility to microbial spoilage. When the moisture content is on the high side, it encourages the growth of microorganisms [31]. Moisture content would therefore indicate low growth of bacteria and fungi [31]. This thus predisposes such food to degradation and enhances its perishability.

All formulated diets have ash contents significantly

(P<0.05) higher than phosphatine except for diet A1, while higher values of crude protein and fats were recorded for all formulated weaning diets compared to phosphatine. The recommended protein content (grams of protein per 100 kcal of food) for complementary foods is of 0.7 g/100 kcal, from 5 to 24 months. In most countries, the protein requirements of infants are met when the energy intake is appropriate, except if there is a predominant intake of low- protein foods [32]. According to the protein Advisory Group, guidelines for weaning foods should be 20% of proteins, fat levels of up to 10%, moisture content 5% to 10% and total ash content not more than 5% [33]. In this study, diets B4, B5, B2 and B6 have higher protein than recommended value while phosphatine contain low (8.25% protein than recommended value. A1, A2, A3 B3 and B6 have accepted or recommended protein values for weaning foods. Diets with these high content of protein can be useful not only for weaning children but also for children already suffering from PEM while phosphatine don't have (low protein) accepted protein recommended.

Fat content of all the formulated diet were higher than that of phosphatine (3.15%) while the fat contents of diet B5, B4, and B2 fall within the recommended range. Low fat content of phosphatine may be necessary to prolong its shelf life also by avoiding lipids peroxidation. Nevertheless, the highest percentage of crude fat compare to Phosphatine could be attributed to the inclusion of oil-dense soybeans in the diet. This attribute tends to agree with the recommendations by FAO/WHO [34] that vegetable oils be included in foods meant for infants and children, which will not only increase the energy density, but also be a transport vehicle for fat soluble vitamins [35]. Lipids in complementary foods should provide approximately 30 to 45% of the total energy required [36, 37] which is enough to guarantee the adequate intake of essential fatty acids, good energy intake and uptake of fat-soluble vitamins [38]. Fat in the diet affects the general intake of nutrients and, if excessive, may exacerbate micronutrient malnutrition in vulnerable populations [38]. Anecdotal evidence suggests that excessive fat intake predisposes to childhood obesity and cardiovascular diseases [39].

Ash content of all the formulated diet as well as that of phosphatine were relatively low. World Health Organisation recommends (5%) ash content for weaning diets. Although ash content of all formulated diets were lower than recommended (5%) value by WHO, they were higher than that of phosphatine and slightly above the recommended range (1.5-2.5%) for seeds and tubers for animal feed formulation defined by Pomeranz and Clifton [40]. This might be due to the inclusion of crayfish, an animal product, in all the diets and hence a high level of mineral elements in these diets.

The composition of foods intended for children under the age of three years is governed by strict specialist legislation (EU Commission Directive 2006/125/EC). Phosphatine was (85.89±0.45%) significantly higher (p<0.05) in total carbohydrate content. Energy content of diet B2 and B4 were comparable to that of phosphatine but significantly higher than other formulated diets. Therefore, the recommended energy intake of complementary foods varies according to the age of the infants, and depends on how much breast milk they ingest, the fat content in breast milk, and the frequency at which they are fed complementary foods. For infants with an average breast milk intake and who eat at least three meals a day containing complementary foods, the recommended energy intake ranges from 0.6 kcal/g at 6-8 months of life to 1 kcal/g at 12-23 months. When breast milk intake is lower or the infants have a growth delay, energy intake should be higher, ranging from 0.8 to 1.2 kcal/g [32].

Table 2. The Proximate Composition and Energy (kcal/100g) Content of Formulated Diets and Phosphatine

Diets	Moisture (g/100g)	Crude protein (g/100g)	Crude fibre (g/100g)	Crude fat (g/100g)	Carbohydrate (g/100g)	Ash (g/100g)	Energy (Kcal/100g)
A1	$5.59±0.05^{b}$	$18.30±1.60^{d}$	$7.37±0.92^{a}$	$7.13±0.91^{d}$	$54.79±0.58^{b}$	$1.84±0.27^{c}$	$356.53±14.75^{bc}$
A2	$4.14±0.06^{b}$	$20.48±1.62^{d}$	$7.22±0.93^{a}$	$4.14±0.22^{e}$	$55.97±0.63^{b}$	$2.05±0.33^{b}$	$343.06±15.53^{bc}$
A3	$4.68±0.03^{b}$	$22.36±1.21^{d}$	$7.07±0.93^{a}$	$5.06±0.13^{e}$	$53.16±0.68^{c}$	$2.17±0.26^{b}$	$347.62±12.35^{bc}$
B1	8.25±0.73	$19.78±0.03^{d}$	$3.48±0.13^{b}$	$4.25±0.38^{e}$	$56.64±3.45^{b}$	$2.54±0.18^{b}$	$343.93±24.52^{bc}$
B2	$5.61±0.28^{b}$	$35.93±1.59^{b}$	$4.48±0.66^{b}$	$11.47±0.48^{b}$	$33.73±1.28^{f}$	$3.79±0.77^{a}$	$381.87±22.34^{ab}$
B3	$8.07±0.47^{a}$	20.87±1.25	$3.57±0.25^{b}$	4.74±0.31e	$55.11±1.29^{b}$	$2.65±0.33^{b}$	$346.58±18.31^{bc}$
B4	$4.55±0.20^{b}$	$42.38±1.74^{a}$	$4.88±0.84^{b}$	$14.35±0.55^{a}$	$24.56±1.28^{g}$	$4.29±0.96^{a}$	$396.91±24.08^{ab}$
B5	$6.31±0.34^{c}$	$31.63±1.49^{c}$	$4.22±0.54^{b}$	$9.54±0.43^{c}$	$39.84±1.28^{e}$	$3.47±0.64^{a}$	$371.74±21.14^{b}$
B6	$7.71±0.45^{a}$	$23.02±1.30^{d}$	$3.70±0.31^{b}$	$5.70±0.34^{e}$	$52.06±1.29^{d}$	$2.81±0.39^{a}$	$351.62±18.98^{bc}$
Phos.	$1.05±0.01^{d}$	$8.25±0.03^{e}$	$0.07±0.00^{c}$	$3.15±0.04^{f}$	$85.89±0.45^{a}$	$1.59±0.14^{c}$	$404.91±3.22^{a}$

Values with different superscript in a column are significantly different (P < 0.05). Phos: Phosphatine

Table 3. The Minerals Composition of the Formulated Diets

Diets	Potassium K (mg/100g)	Calcium Ca (mg/100g)	Magnesium Mg (mg/100g)	Iron Fe (mg/100g)	Phosphorus P (mg/100g)	Manganese Mn (mg/100g)	Sodium Na (mg/100g)	Zinc Zn (mg/100g)
A1	241.87±1.94	75.67±2.18	441.32±496.53	10.53±0.50	210.78±6.88	18.12±0.19	88.17±2.60	1.47±0.01
A2	338.56±2.64	85.09±2.73	624.17±74.48	10.21±0.49	231.63±7.52	18.24±0.19	87.10±2.54	1.64±0.01
A3	434.96±2.98	94.01±2.57	807.00±9.41	9.88±0.48	251.85±7.26	18.37±0.19	84.83±0.78	1.81±0.03
B1	365.16±61.83	536.42±19.79	468.28±492.18	24.12±1.22	295.22±4.33	27.58±2.50	79.12±2.06	16.49±0.79
B2	1048.88±6.58	353.81±6.58	1914.43±24.05	14.06±0.33	410.59±11.67	23.28±1.05	75.82±1.73	9.46±0.08
B3	410.97±2.95	524.43±2.82	646.51±74.25	23.45±0.28	303.13±6.87	27.25±2.03	78.90±1.75	16.02±0.12
B4	1322.27±9.79	280.69±8.20	2457.82±32.97	10.04±0.35	456.65±13.73	21.58±0.62	74.50±1.73	6.65±0.06
B5	866.62±6.37	402.56±5.51	1552.17±19.11	16.75±0.32	379.89±10.30	24.42±1.33	76.70±1.74	11.33±0.09
B6	502.10±3.63	500.05±3.36	827.64±9.22	22.11±0.28	318.49±7.56	26.68±1.89	78.46±1.74	15.08±0.11
Phos	123.00±0.34	50.50±0.38	56.00±0.99	8.04±0.00	567.00±1.00	0.71±0.00	0.01±0.00	2.30±0.06

Phos.: Phosphatine . Values with different superscript in a column are significantly different (P < 0.05). Phos: Phosphatine

3.1.2. Minerals Content of the Formulated Diets

The mineral composition of the dietary samples is shown in Table 3. Except for phosphorus, the values for calcium, potassium, iron, zinc, sodium, magnesium, and manganese of all the diets were significantly higher compared with the control. B6, B3 andB1 had the highest content of iron, while B6, B3, B1, B5 had the highest calcium content, compared with the others. It was discovered that some of the minerals were lower in values compared to the requirement for weaning diet, while some of the mineral values were within the recommended daily allowance for weaning diets such as in calcium and iron.

To meet the nutritional mineral requirements of infants, a variety of mineral-rich complementary foods should be offered, since the consumption of these foods is relatively small among infants/children aged between 6 and 24 months [32]. From 9 to 11 months of life, the amount of minerals that should be provided by complementary foods is high: 97% for iron, 86% for zinc, 81% for phosphorus, 76% for magnesium, 73% for sodium and 72% for calcium [36, 37]. The recommended iron intake is 4 mg/100 kcal from 6 to 8 months, 2.4 mg/100 kcal from 9 to 11 months and 0.8 mg/100 kcal from 12 to 24 months; all our formulated diets fall within this range.

3.2. Functional Properties

The water absorption capacity (WAC) gives an indication of the amount of water available for gelatinization [42]. Table 4 shows that formulated samples were significantly lower in WAC compared to the control, the values ranging between 2.75–3.90 ml/g. This may be as a result of production of liquid gruel due to breakdown of starch by the enzymes, which leads to reduction in water absorption capacity and the release in the water trapped in the gel [43, 44]. The highest WAC, OAC and LH values were consistently for the reference samples (4.65±0.21, 2.90±0.99 and 0.62 respectively), while diet B2hadthe highest WAC (3.90±0.42) and diet B1 the highest OAC compared to other formulated diets; The high WAC of the reference sample could be attributed to the high temperature employed during drying process and cooking of the product that can provoque more protein-water interaction during Protein denaturation, starch gelatinization and swelling of the crude fibre, used for processing the rice and soya beans into flour [45].

The Bulk density (BD) is a reflection of the load the sample can carry if allowed to rest directly on one another. The lower the BD value, the higher the amount of four particles that can stay together and thus increasing the energy content that could be derivable from such diets [46]. The BD values of the formulated weaning samples were significantly ($p<0.05$) greater than value for Phosphatine Reference sample (0.36±0.01). The Packed Bulk Density (PBD) represents the highest attainable density with compression. The locally made diets had the highest PBD value range 0.64-0.81g/ml) and the values were significantly comparable among diets. Loose Bulk Density (LBD) represents the lowest attainable energy without compression. There was significant ($p<0.05$) difference in the LBD values of the samples. The formulated diets had the greatest LBD value of 0.70±0.00 forB1. The high bulk density values of the formulated weaning diets indicate that more of the samples could be prepared using a high amount of water yet giving the desired energy nutrient density and semi-solid consistency which can easily be fed to an infant [46].

The swelling index (SI) values showed a significant ($p< 0.05$) difference among the samples. Diet B5 had the lowest value compared to the rest of diet and B3, A1, B1 and B6 had high values while the Reference sample had the least (1.0) SI value. the increase in swelling of the diets, could be as a result of no enzymes (amylase) release to breakdown or (denaturation) the starch into dextrin-maltose which swell so well when cooked because the Swelling Index depends on the compositional structure of the sample [43, 44].

Table 4. Functional Properties of Formulated Weaning Diets

Diets	WAC (ml/g)	OAC (ml/g)	LBD (g/ml)	PBD (g/ml)	FC (%)	SI	% Dispersibility
A1	3.00±0.00^{c}	1.30±0.14^{b}	0.50±0.14^{e}	0.78±0.01^{a}	13.21±0.00^{a}	2.00±0.00^{b}	65.00±1.41^{b}
A2	3.00±0.00^{c}	1.40±0.14^{b}	0.58±0.01^{b}	0.80±0.01^{a}	11.11±0.00^{b}	1.50±0.00^{e}	65.00±7.07^{b}
A3	3.05±0.35^{b}	1.50±0.00^{b}	0.60±0.00^{b}	0.79±0.03^{a}	10.52±2.72^{abc}	1.70±0.00^{c}	62.50±3.54^{b}
B1	3.30±0.28^{b}	1.75±0.35^{a}	0.70±0.00^{a}	0.81±0.06^{a}	8.58±1.04^{c}	2.00±0.00^{b}	63.00±0.14^{b}
B2	3.90±0.42^{b}	1.20±0.00^{b}	0.55±0.01^{d}	0.76±0.01^{a}	8.51±1.10^{c}	2.00±0.00^{b}	61.50±0.35^{b}
B3	3.00±0.00^{c}	1.15±0.07^{b}	0.58±0.02^{b}	0.71±0.11^{c}	7.62±0.08^{c}	2.33±0.00^{a}	65.00±0.00a^{b}
B4	2.60±0.14^{c}	1.35±0.21^{b}	0.48±0.01^{f}	0.64±0.01^{c}	10.49±1.06^{abc}	1.67±0.00^{d}	63.50±0.21^{ab}
B5	3.25±0.35^{b}	1.15±0.07^{b}	0.51±0.01^{e}	0.72±0.00^{b}	9.4±1.71^{bc}	1.25±0.00^{f}	62.50±0.35^{ab}
B6	2.75±0.35^{c}	1.05±0.07^{b}	0.57±0.01^{c}	0.73±0.01^{b}	8.66±0.96^{c}	2.00±0.00^{b}	65.00±0.71^{ab}
Phos.	4.65±0.21^{a}	2.90±0.99^{a}	0.31±0.00^{g}	0.36±0.01^{d}	13.56±2.03^{a}	1.00±0.00^{g}	17.5±1.77^{c}

Values with different superscript in a column are significantly different ($P < 0.05$). Phos.: phosphatine

The results for foam capacity are given in Table 4. The values ranged between 7.62 for Diet B3 and 13.21 for Diet A1. The Foam capacity for the commercial weaning food was 13.56, significantly greater than that for the formulated diets but comparable with A1 and A3, while the foaming capacities of diets B1 to B6 were not significantly different at $p>0.05$. Some of These results were similar to those obtained by Kouakou et al. [47] for weaning food formulated from cereals and legumes which ranged from 0.00 to 10.00%. Indeed, proteins are denatured and aggregated during cooking and agitation leading to foam formation [48] even if the was not stability of foam over time. It has been reported that the native proteins provide high foam stability than denatured proteins [48]. Moreover, the low or absence of foaming capacity of certain meals could affect their stability during storage.-The results for dispersibility are given in Table 4. The dispersibility was within the range 61.0 to 65.0 for Diets while Phosphatine had a dispersibility value of 17.10, which was significantly lower than those of the formulated diets. There was no significant difference between diets. The results obtained by Kulkarni *et al.* [29] on diets formulated from green gram, sesame and sorghum malt flour ranged from 71% to 75% hence were lower than those of the formulated diets A1 to B6. The dispersibility of a diet in water indicates its reconstitutability. The higher the dispersibility value, the better the diet, hence formulated diets were more suitable in preparing weaning foods due to its high dispersibility values.

3.3. Sensory Analysis

Table 5 shows the result of the sensory evaluation of the samples. There was a significant ($p < 0.05$) difference in the colour ratings of the samples by the panellists compared to control. The Reference sample was significantly ($p < 0.05$) rated best, while samples B2 and A3 had the least colour rating. However, the rating scores were within acceptable range from 5.50–8.43. Factors that may have affected the colour of the composite blends include the chemical composition of the crayfish and soya bean, the drying temperature and duration, composition ratio of crayfish and soya bean flours. Low colour ratings of weaning foods can decrease the acceptability as colour is an important organoleptic attribute which enhances the product acceptability. The colour ratings of the evaluated samples were within acceptable limits and therefore would not be unappreciable to the infants, but could be further improved by adjusting processing conditions

The consistency or texture ratings of the samples ranged from 6.19-7.86. There was no significant ($p < 0.05$) difference between the Reference sample and samples B3 and B4. The Reference sample had the best consistency rating, and was followed by sample B3, while sample B1 received the least consistency ratings of 6.19. WAC and SI are important parameters which determine the consistency of flour. A very thick consistency would need increased effort to swallow, and therefore may limit the food intake in young children who have not fully developed their ability in these aspect [49].

There was a significant difference ($p < 0.05$) between the taste of the Reference Sample and that of the formulated composite blends. However, in general the taste ratings of the formulated samples were not significantly different ($p < 0.05$) except sample A3 having the least value. The Reference sample had the best rating in taste, followed by Sample B2 and B4, and then closely followed by Sample B5. However, the taste ratings of the samples were within acceptable range. The best score rating of the Reference would be as a result of flavouring addition in the product, as infants are likely to reject unflavoured foods. Therefore, to further improve the taste ratings, flavour additives might be required to be incorporated into the formulated samples.

The aroma (flavour) ratings of the samples ranged from 5.37–8.36. The Reference sample was rated best for aroma, followed by sample B4. The sample rating scores were within a favourable range and thus the ratings compared favourably with each other. The best score rating for the Reference could be a result of the added flavourings. The high aroma rating of sample of B4 could be due to the presence of flavour imparted by the oils in the soya beans (which was present in a higher ratio as compared to the other formulated diets. However, the aroma ratings of the samples were within acceptable range.

Table 5. Results of Sensory Evaluation of the Formulated Diets

Samples	Colour	Taste	Flavour	Texture	Overall Acceptability
A1	6.38^{b}	6.63^{b}	6.19^{b}	6.48^{b}	6.30^{b}
A2	5.85^{b}	6.37^{b}	6,18^{b}	6.48^{b}	6.15^{b}
A3	5.50^{b}	5.78^{c}	5.37^{b}	5.92^{c}	5.41^{b}
B1	6.52^{b}	6.22^{b}	5.89^{b}	6.19^{b}	5.96^{b}
B2	5.85^{b}	7.15^{b}	6.44^{b}	6.70^{b}	6.67^{b}
B3	6.70^{b}	6.37^{b}	6.15^{b}	7.00^{a}	6.26^{b}
B4	6.26^{b}	7.30^{b}	6.63^{b}	6.88^{a}	6.89^{a}
B5	6.56^{b}	6.78^{b}	5.93^{b}	6.32^{b}	6.64^{b}
B6	6.36^{b}	6.61^{b}	5.93^{b}	6.21^{b}	6.46^{b}
Phosphatine	8.43^{a}	8.32^{a}	8.36^{a}	7.86^{a}	8.39^{a}

Values with different superscript in a column are significantly different ($P < 0.05$)

There wasn't much significant difference ($p < 0.05$) in the overall acceptability ratings of sample B4 and the Reference sample, though the Reference received higher rating. However the overall acceptability of the samples B1, B2, B3, B5 and B6 were within acceptable range.

3.4. Rat Bioassay

Rat growth parameters, PER and FER assessment by rat bioassay are shown in Table 6. Results revealed that Rats fed with diet B2, B3 and A1 had the best growth while those fed with diet B6 and phosphatine produced the least (Table 6). Formulated weaning foods had PER values ranging from 1.53 to 3.63. Diet A1, A2, A3, B1, B2 and B3, had higher values than the commercial Phosphatine. The FER ranged between 0.12 and 0.22 for the formulated weaning diets, the commercial diet and diet A2 had lower values. Table 7 presents the body-weight ratio of rats fed on the formulated traditional diets. Rats fed with A2, B1, B2, B3, B5 and B6 have better growth in their liver while the better kidney growth was found in the rats fed with A1, A2, A3. B3, B4, B6 and Phosphatine had the same growth response. B1 produced the best growth in the heart of rats. Rat fed with Phosphatine had the smallest liver, kidney and heart compared to rats fed formulated diets. This may due to the high protein content of the formulated diets compared to the protein content of phosphatine.

Table 6. Growth Response of Albino Rats Fed With Different Composed Traditional Diets and Phosphatine

Diets	Body weight(g)						
	Initial(g)	Final (g)	Weight Gain (g)	Protein intake(g)	Food intake (g)	PER	FER
A1	41.45±2.05^{a}	107.9±6.08^{bc}	66.45±8.13^{ab}	18.30	428.71	3.63	0.16
A2	35.85±3.46^{a}	84.95±3.04^{d}	51.25±3.46^{b}	20.48	427.08	2.50	0.12
A3	37.00±3.11^{a}	101.75±0.21^{c}	64.75±2.90^{b}	22.36	417.74	2.90	0.16
B1	40.70±0.57^{a}	106.55±15.91^{abc}	65.85±15.34^{b}	19.78	598.64	3.33	0.11
B2	40.15±1.34^{a}	135.85±18.0^{a}	95.70±16.69^{a}	35.93	562.94	2.66	0.17
B3	43.25±0.21^{a}	114.15±1.06^{b}	70.90±0.85a^{b}	20.87	322.27	3.40	0.22
B4	43.20±1.56^{a}	94.20±30.69^{abc}	56.00±22.06^{b}	42.38	283.33	1.20	0.18
B5	38.85±1.34^{a}	91.00±37.62^{abcd}	52.15±38.96^{b}	31.63	316.06	1.65	0.17
B6	41.05±2.19^{a}	74.80±15.13^{d}	12.30±17.39^{c}	23.02	243.45	1.53	0.15
Phos.	42.25±3.18^{a}	52.05±2.76^{e}	9.65±0.64^{c}	8.25	117.20	1.78	0.13

Values with different superscript in a column are significantly different ($P < 0.05$). Phos.: Phosphatine

Table 7. Body-Weight Ratio of Rats Fed on the Formulated Diets

Diets	Liver	Kidney	Heart
A1	4.70±0.28a	1.10±0.14a	0.4±0.14bcd
A2	5.20±0.57a	1.05±0.07a	0.35±0.07bd
A3	3.40±0.42b	0.95±0.07a	0.35±0.21bcd
B1	5.90±0.99a	0.60±0.00b	0.60±0.00a
B2	5.60±0.00a	0.63±0.11b	0.50±0.00b
B3	4.30±0.57ab	0.55±0.00c	0.50±0.00b
B4	4.20±0.00b	0.50±0.00c	0.40±0.00c
B5	4.45±1.06a	0.60±0.00b	0.40±0.00c
B6	5.00±3.11a	0.60±0.14bc	0.33±0.04d
Phos	2.25±0.78c	0.50±0.00c	0.25±0.07d

Phos. : phosphatine

3.5. Microbial Analysis

Microbial analysis was conducted on freshly prepared diets to determine if blends are wholesome for consumption and data is presented in figure 2. Bacterial counts were low < 10cfu/ml), however high counts were obtained for mould and yeast (0.75 and 1.20 x 102cfu/ml respectively). But a food product for consumption should have microbial count below1x105cfu/g. The international microbiological standard recommends a bacteria contaminants limit of less than 106cfu/ml for food [50]. Low bacteria counts were obtained as a result of high standard of personal hygiene, high temperature of drying process (80°C-100°C) and quality maintenance of good manufacturing practices observed during the food formulation process.

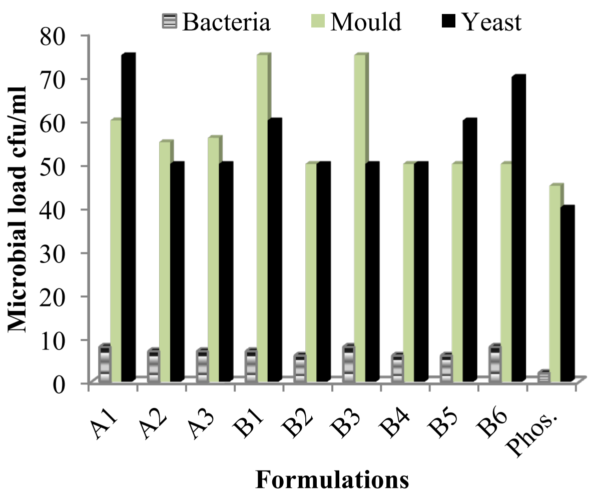

Figure 2. Microbial load of the formulations

4. Conclusions

Children in the developing countries are the most vulnerable and affected by malnutrition. Inappropriate calorie intake and faulty or absence of complementary feeding after six month of age is considered as one of the major factor for the child malnutrition. *This study revealed that ready-to-eat complementary food products formulated from locally available food commodities, can meet the macro nutritional needs of infants and children. However certain aspects like the digestibility and bio-availability of the macronutrients in these local diets as well are vitamins fortification and flavor and aroma incorporation. need further investigations The results from this study suggests therefore that proper reformulation and fortification of these local diets can provide nutritious foods that are suitable not only for weaning, but also as rehabilitation diet to malnourished children and can be more cost effective. This is believed to be a practical food-based approach aimed at combating the problem of malnutrition among infants and children in Cameroon and other developing countries.*The results have shown that the formulated weaning food prepared from soya beans, crayfish, Irish potatoes, rice, carrot and sugar had protein content which conformed to the FAO/WHO recommended value of 10%. The results of the growth response further revealed that these formulated weaning food blends was nutritionally comparable with the reference diet Phosphatine, indicating that the underutilized crops used in this study which are locally available could be used in producing good weaning foods that can promote and combat malnutrition.

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