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Proximate analysis of low-cost locally produced weaning foods and its safety aspects, in comparison to imported weaning foods

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Abstract

Malnutrition is a persistent health problem among children in Bangladesh, especially under 2 year's children due to the lack of proper weaning foods both diverse and balanced. Highly nutritive locally produced weaning foods were prepared using locally available food resources to ensure the availability of low-cost weaning food in Bangladesh. The developed foods were evaluated for their nutritional characteristics and microbiological quality. The food (L-1) contained the major nutrients like moisture, ash, fat, protein, fiber, carbohydrate, and energy respectively 2.96%, 3.13%, 9.45%, 15.56%, 0.07%, 59.12%, and 394.1 kcal/ 100 g, and (L-2) 2.08%, 3.09%, 9.3%, 16.09%, 0.08%, 59.74%, and 397.5 kcal/ 100 g, respectively which were comparable to those of the three good quality imported commercial weaning foods F-1, F-2, and F-3. The vitamin A, iron, and calcium contents were significantly different ($p<0.05$) than the commercial foods. The overall bacteriological status of the prepared and imported commercial weaning foods was observed to be satisfactory. The costs of the locally prepared weaning foods are considerably cheaper than the three imported commercial weaning foods of the same quality and suitable for low-income people of Bangladesh.

Keywords: Weaning Food; Low Cost; Locally produced; Rice; Wheat; Commercial

1. Introduction

Millions of children in the tropical, subtropical, and least-developed areas of the world suffer from malnutrition with those at the complementary feeding stage being most vulnerable [1, 2].

Additionally, the low nutrient density of complementary foods further accounts for under-nutrition resulting in Protein Energy Malnutrition (PEM) as well as micro-nutrient deficiencies [1, 3].

Globally, optimal breastfeeding could prevent 13% of deaths of children aged less than five years while appropriate complementary feeding (CF) practices might result in an additional 6% reduction in under-five mortality, especially in developing countries as ours [4].

According to the Bangladesh Demographic and Health Survey [5], almost one-third of children under five years are underweight (36%) and 41% are stunted. Only 64% of infants aged less than six months are exclusively breastfed and

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almost one-third (29%) of children aged 6 to 23 months received a minimum acceptable diet [5]. The most common complementary foods include khichuri, bhaat dal, suji and muri (puff rice) [6].

In most developing countries, commercial weaning foods of excellent quality either imported or locally produced are generally 10 to 15 times higher than the cost of the common staple foods due to sophisticated processing, expensive packing, extensive promotion, and solid profit margins [7].

Therefore, development of supplementary foods based on locally available cereals and legumes has been suggested by the Integrated Child

Development Scheme (ICDS) and Food and Agriculture Organization (FAO) to combat malnutrition among mothers and children of low socio-economic groups [8].

A highly nutritive weaning food prepared from rice and milk in Cereal Technology section, IFST, BCSIR, Dhaka and safety aspects of it was compared to imported commercial weaning foods [9]. Rice alone constitutes 92% of the total food grains produced annually in Bangladesh. It provides about 80% of people's energy intake, the majority of their protein intake, and a considerable proportion of several micro-nutrients in their average daily diet. [10]. At present, there are no instant weaning foods manufactured in Bangladesh from locally available food resources and all the weaning foods available in the local markets are imported commercially [8].

Bangladesh is a highly dense populated poor country and due to urbanization, an increasing number of women in Bangladesh are working outside of their homes. So the demand for instant or ready-to-use complementary feeding (weaning food) with good quality of diversity, as well as low price, is increasing day by day to ensure proper complementary food for children 6-23 months.

Thus, in this study, cereal-based weaning food is collected from local markets to ensure the quality of the products available of low-cost weaning food that is microbiologically safe to reduce infant malnutrition and mortality rates. We also compare the nutritive value of the locally produced weaning food with the available imported commercial weaning foods in Bangladesh.

The locally available weaning food has been compared with three imported foreign weaning foods available in Dhaka by analyzing their essential nutrients.

2. Material and methods

2.1. Collection of imported commercial weaning foods and locally produced weaning food

The three imported commercial weaning foods (Wheat-milk-based weaning food as F-1, rice-milk-banana based weaning food as F-2, and milk-based weaning food from another company as F-3) were selected based on their popularity and market availability. These three commercial weaning foods are recommended for children aged 6 months and above. These weaning foods were purchased from supermarkets in Bangladesh.

Locally produced weaning foods are prepared of rice, Wheat, sugar, skim milk powder, butter, etc (Rice-milk-based weaning food as L-1 and Wheat-milk-based weaning food as L-2).

2.2. Chemical analysis of weaning foods

2.2.1. Nutrient analysis

The nutrient compositions of the imported commercial weaning foods and as well as the locally produced weaning foods were carried out as follows:

2.2.2. Determination of moisture content

Moisture content was determined by oven-dry method as the loss in weight due to evaporation from the sample at a temperature of 105 °C. The weight loss in each case represented the amount of moisture present in the sample:

$$\text{Moisture (\%)} = (\text{Weight of the original sample} - \text{weight of the dried sample}) / \text{weight of the original sample} \times 100$$

2.2.3. Determination of crude protein

The crude protein content was determined following the micro Kjeldahl method (AOAC, 2005) [11]. The percentage of nitrogen (N) was calculated using the following equation:

$$\text{Nitrogen (\%)} = (S - B) \times N \times 0.014 \times 100 / W$$

Where
S= Titration reading for sample,
B= Titration reading for blank,

V = titration volume = (S-B), N= Strength of N/70 H_2SO_4, W = Weight of the sample, 0.014 = Constant value.

Crude protein was obtained by multiplying the corresponding total nitrogen content by a conventional factor of 6.25. Thus, crude protein (%) = % of N × 6.25.

2.2.4. Determination of crude fat

Crude fat was determined by the soxhlet extraction technique followed by AOAC (2005) [11]. The fat content of the dried samples was easily extracted into an organic solvent (petroleum ether) at 60 to 80°C and followed to reflux for 6 h. The percentage of fat content was calculated using the following formula:

$$\text{Crude Fat (\%)} = \text{Weight of the fat in the sample} / \text{Weight of the dried sample} \times 100$$

2.2.5. Determination of ash

Ash content was determined by combusting the samples in a muffle furnace at 600°C for 8 h according to the method of AOAC (2005) [11]:

$$\text{Ash Content (\%)} = \text{Weight of ash} / \text{Weight of sample} \times 100$$

2.2.6. Determination of crude fiber

The bulk of roughage in food is referred to as the fiber and is called crude fiber. The milled sample was dried, defatted with ethanol ethanol-acetone mixture, and then the experiment was carried out using the standard method as described in AOAC (2005) [11]:

$$\text{Crude Fiber (\%)} = (\text{Weight of the residue} - \text{Weight of the Ash}) / \text{Weight of the sample} \times 100$$

2.2.7. Determination of carbohydrate

The carbohydrate content was estimated by the difference method. It was calculated by subtracting the sum of the percentage of moisture, fat, protein, and ash contents from 100% according to AOAC (2005) [11]:

$$\text{Carbohydrate (\%)} = 100 - (\text{moisture\%} + \text{fat\%} + \text{protein\%} + \text{ash \%})$$

2.2.8. Determination of total energy

The total energy value of the food formulation was calculated according to the method of Mahgoub (1999) using the formula as shown in the following equation:

$$\text{Total energy (kcal/100 g)} = [(\text{\% available carbohydrates} \times 4.1) + (\text{\% protein} \times 4.1) + (\text{\% fat} \times 9.3)]$$

2.2.9. Determination of vitamin A

About 10 g of the sample was homogenized, weighed, and transferred into a ground bottom flask, 30 ml of extraction solution, 0.1% antioxidant, and a few drops of KOH was added and refluxed for 30 min at 70°C. The sample was cooled down, vitamin A was extracted into hexane, and the combined hexane extract was washed with water and then dried the hexane layer to about 2 ml on a water bath or rotary evaporator. The final volume was made up to 50 ml with the mobile phase. The mobile phase, standard and sample were filtered through a 0.45 µ membrane filter and were degassed before injection. Calibration curve was made by a standard in the mobile phase with five point calibrations and analyzed independently by HPLC. A standard curve was plotted between the concentration of vitamin A and peak area obtained. For HPLC analysis, an Eelipse × BD – C18 column (4.6 × 250 mm 5 µm) was used with a linear gradient of methanol: water (95:5) at a constant flow rate of 1 ml /min by using a binary pump with column temperature 40°C. A multiple-wavelength detector was employed for the detection of pecks using a wavelength of 325 nm and a bandwidth of 8 nm.

2.2.10. Determination of minerals

The mineral contents were determined after the ash content determination. The ash residue of each formulation was digested with perchloric acid and nitric acid (1:4) solution. The samples were left to cool and contents were filtered through Whatman filter paper 42. Each sample solution was made up to a final volume of 25 ml with distilled water. The aliquot was used separately to determine the mineral contents of Fe and Ca by using an Atomic Absorption Spectrometer (Spectra AA 220, USA Varian).

2.3. Determination of microorganisms

A microbiological examination of the weaning foods was performed to assess bacterial, fungal, and yeast load under laboratory conditions. Standard Plate Count (SPC), fungal and yeast count, and enumeration of total coliform and Salmonella of the weaning foods were examined according to BAM [12]. The plate count method was employed for the examination of the total number of viable microbes present in the sample. Standard plate count (SPC) was estimated by decimal dilution technique followed by pour plate method and spread method for fungus and yeast. The streak plate method was used to isolate the specific micro-organism. Isolation and enumeration of total coliform were performed by the most probable number (MPN) method using MacConkey broth [13].

2.4. Estimation of cost

The cost of locally produced weaning food was depends on the price of the materials used in preparing the food, gas, electricity, jars, water, labor cost and others. The price of the locally produced food was compared with the market price of the three imported commercial baby foods at the same time.

2.5. Statistical analysis

The data were analyzed using SPSS version 17.0. The mean and standard deviations of the triplicate analyses were calculated. The analysis of variance (ANOVA) was performed to determine significant differences between the means using Dunnett's T3 tests.

3. Results and discussion

3.1. Nutritional composition

Table 1 Nutritive Value of the Locally Produced Weaning Food as compared with Imported Commercial Weaning Foods

Baby food sample	Moisture (%)	Ash (%)	Fat (%)	Protein (%)	CHO (%)	Fiber (%)	Energy (K.Cal)
L-1	2.961	3.132	9.450	15.560	59.127	0.074	394.10
L-2	2.084	3.086	9.297	16.088	59.738	0.086	397.54
F-1	2.349	1.869	7.630	14.670	68.764	0.307	413.04
F-2	4.011	2.578	6.548	16.593	64.940	0.573	395.18
F-3	2.565	1.719	11.166	15.744	77.395	0.0	485.72

The nutritional compositions (g/100 g dry weight) of the locally produced weaning food and imported commercial weaning foods were summarized in Table 1. The energy content of the locally produced weaning food was 394.1 & 397.54 kcal/100 g. For the imported commercial weaning foods, the energy content ranged from 395.18 to 485.72 kcal/100 g. For all the weaning foods both locally produced and commercial, the energy density per 100 g of the dry food was lower than the minimum energy (483.9 kcal/100 g) recommended in the Codex Alimentarius Standards for weaning/follow-up foods [14].

Protein is one of the most important nutrients required in weaning foods. The locally produced weaning foods had a protein content of 15.56% and 16.09 which are the same as specified in Codex Alimentarius standards. The protein levels of commercial weaning foods ranged from 14.67 to 16.59% (one lower than the RDA and another two is slightly higher than RDA) which almost the same as locally produced weaning foods. According to FAO/WHO Codex Alimentarius Standards for follow–up/ weaning foods, the protein content should range from 14.52 to 37.70 g/100 g [14].

The locally produced weaning food contained 9.45% and 9.39% fat which was significantly higher ($p<0.05$) than the commercial weaning foods of F-1 and F-2 but lower than F-3; ranging from 6.55 to 11.17% but lower than the specified amount in the Codex Alimentarius Standards (range 14.52- to 41.13%). The lower fat content contributed to the lower energy value of the locally produced weaning food. The lower fat content may also have contributed to the increase in the shelf-life of the formulation by decreasing the chances of rancidity [15]. Ash content is an important nutritional indicator of mineral content and an important quality parameter for contamination, particularly with foreign matter (for example, pebbles

The ash content of the locally produced weaning foods was 3.13% & 3.09% for L-1 and L-2 accordingly; this result was significantly higher than the commercial weaning foods (F-1: 1.87%, F-2: 2.58& and F-3: 1.72%). No standard for ash concentration has been specified for weaning/follow–up foods in the Codex Alimentarius Standards [14].

The moisture content of the locally produced weaning food for L-1 and L-2 were 2.96% and 2.08% respectively. These results were significantly different from the commercial weaning foods F-2 (4.01%) and within the range of F-1 and F-3 (F-1: 2.35% and F-3: 2.57%) (Table 1).

The percent crude fiber of the locally produced weaning food was 0.074% and 0.086% (Table 1). These values were significantly higher than the value of commercial weaning foods which ranged from 0.00 to 0.573%. Fiber is an important dietary component in preventing overweight, constipation, cardiovascular disease, diabetes, and colon cancer [16].

The carbohydrate content in the locally produced weaning foods was 59.13% and 59.74% for L-1 and L-2 (Table 1). This result was significantly ($p<0.05$) lower than the commercial weaning foods which ranged from 64.94 to 77.4%. The carbohydrate levels of the locally produced weaning food and all the imported commercial weaning foods were within the standard limit (41.13 to 73.79 g/100 g) of the Codex Alimentarius Standards [14]. Vitamins are substances that are indispensable for the growth and maintenance of good health.

According to Food and Nutrition, Institute of Medicine [17], the recommended daily allowances (RDA) for energy, carbohydrate, protein, fat, vitamin A, vitamin B1, Ca, and Fe for 7 to 12 months old infants are 743 kcal, 95 g, 11 g, 30 g, 500 µg, 0.3 mg, 270 mg, and 11 mg, respectively.

Table 2 Comparison of Recommended Daily Allowance (RDA) meet by the weaning foods

Nutrient of the weaning food	Recommended Daily Allowances (RDA)	L-1	L-2	F-1	F-2	F-3
Calorie	743 Kcal	53.0%	53.5%	55.6%	53.2%	65.4%
CHO	95g	62.2%	62.9%	72.4%	68.4%	81.5%
Protein	11g	141.5%	146.3%	133.4%	150.8%	143.1%
Fat	30g	31.5%	31.0%	25.4%	21.8%	37.2%
Vitamin-A	500 µg	188.8%	178.4%	177.7%	279.6%	390.6%
Vitamin-B	0.3 mg	186.7%	123.3%	116.7%	23.3%	10.0%
Calcium	270 mg	162.7%	156.9%	120.5%	167.0%	169.7%
Iron	11 mg	67.6%	66.9%	66.0%	13.1%	43.7%

These findings suggest that both locally produced and commercial weaning foods have the potential to provide the recommended daily requirements for energy and other nutrients for infants and young children. These foods, however, may be unable to meet the RDAs for energy and macro/micronutrients as the children grow older due to increased demand for nutrients to support growth.

3.2. Quality evaluation

In a well-balanced weaning food, 13% of the total energy is usually derived from protein, 26% from fat, and 61% from carbohydrates, respectively [18]. The locally prepared weaning foods had higher concentrations of calories from fats and protein than the recommended values (Table 3). The locally produced weaning foods L-1 & L-2 and the imported commercial weaning foods F-1, F-2, and F-3 provided 61.51, 61.64, 68.26, 67.37, and 65.33% of the total calories from carbohydrates which meet the recommendation of well-balanced weaning food.

Table 3 Percent calories from different nutrients of weaning foods

Weaning foods	Percent calories		
	Protein	Carbohydrate	Fat
L-1	16.19	61.51	22.3
L-2	16.60	61.64	21.76
F-1:	14.56	68.26	17.18
F-2:	17.22	67.37	15.41
F-3:	13.29	65.33	21.38

% Protein calories = Protein% X 4/ Total energy of formulations; % Carbohydrate calories = Carbohydrate % X 4/ Total energy of formulations; % Fat calories = Fat % X 9 / Total energy of formulation.

Table 4 Vitamin-A & Vitamin-B1 Content in the locally produced and Market Weaning Foods

Baby food sample	Vitamin-A (IU/100g)	Vitamin-A (µg /100 Kcal)	Vitamin-B1 (mg/100mg)	Vitamin-B (µg/100 kcal)
L-1	944.66 (±0.577)	71.86	0.56 (±0.042)	142.10
L-2	892.00 (±1.2)	67.31	0.37 (±0.014)	93.07
F-1	888.66 (±0.577)	64.54	0.35 (±0.028)	84.74
F-2	1398.00 (±1.0)	106.13	0.07 (±0.007)	17.71
F-3	1953.66 (±1.527)	120.63	0.03 (±0.002)	6.18

According to Codex Alimentarius Standards [14], the recommended levels (µg/100 kcal) of vitamin A for processed cereal-based foods for infants and young children range from 60 to 180 µg/100 kcal. On comparing with this standard, the locally produced weaning foods L-1 and L-2 had a vitamin A content of 71.86 & 67.31 µg/100 kcal respectively and the imported commercial weaning foods F-1, F-2, and F-3 had vitamin A content of 64.54, 106.13, and 120.63 µg/100 kcal, respectively which were above the minimum limit (60 µg/100 kcal) specified in the Codex Alimentarius standards.

The locally produced weaning foods L-1 and L-2 had a vitamin B1 content of 142.1 and 93.07 µg/100 kcal (Table 4). For the imported commercial weaning foods, F-1, F-2, and F-3 had vitamin B1 content of 84.74, 17.71, and 6.18 µg/100 kcal respectively. The vitamin B1 contents of the locally produced weaning food and the commercial weaning foods were higher than the minimum amount (60 µg/100 kcal) specified in the Codex Alimentarius Standards [14].

Table 5 Minerals Content in the locally produced and Imported Weaning Foods (mg/100gm).

Baby food sample	Iron	Calcium
L-1	7.44 (±0.095)	439.26 (±0.94)
L-2	7.36 (±0.038)	443.63 (±0.58)
F-1:	7.26 (±0.042)	325.29 (±0.84)
F-2:	1.44 (±0.096)	450.86 (±0.28)
F-3:	4.81 (±0.062)	458.21 (±0.23)

Calcium is an essential element in infants and young children for building bones and teeth, function of muscles and nerves, blood clotting, and immune defense [19]. The concentration of Ca of the locally produced weaning foods lL-1 & L-2 were 439.3 and 443.6 mg/100 g which are significantly different from the imported commercial weaning foods F-1, F-2, and F-3 by 325.3, 450.9, and 458.2 mg/100 g, respectively (Table 5). According to the Codex Alimentarius standards, Ca concentrations in weaning foods should not be less than 435.51 mg/100 g of dry food. Based on this standard, the locally produced weaning food and all the imported products, except F-1 had the Ca concentrations above the minimum amount (435.51 mg/100 g) specified in the Codex Alimentarius Standards [14].

Iron is an essential micronutrient for the synthesis of hemoglobin (an oxygen carrier in the red blood cells), myoglobin (used for muscle contraction), and enzymes/coenzymes (used in various metabolic pathways). Iron also enhances the body's immune system thus, reducing infections and fostering proper functioning of other organs of the body [19]. Iron concentrations in the locally produced weaning foods L-1 and L-2 were 7.44 & 7.36 mg/100 g (Table 5); while in the imported commercial weaning foods the concentration of F-1, F-2, & F-3 were 7.26, 1.44 & 4.81 mg/100 g respectively. The Locally produced weaning food and all the imported products had iron concentrations above the minimum amount (4.8 mg/100 g) except F-2 specified in the Codex Alimentarius Standards [14].

3.3. Microbiological quality of weaning foods

The overall bacteriological status of the locally produced and the imported commercial weaning foods was observed to be satisfactory (Table 6). The obtained results revealed that the total viable bacterial count, total yeast and mold count, total coliform count and presence of Salmonella per gram were absolutely nil/g in all weaning foods analyzed; when packets were opened. The low counts of the examined foods indicated adequate thermal process, good quality of raw materials, and as a result of the good. Different processing conditions under which the production of foods was carried out.

Table 6 Comparative Microbiological Load of Weaning Foods

Baby food sample	Total viable count (CFU/g)	Yeast and mold count (CFU/g)	Total Coliform count (CFU/g)	Salmonella/g
L-1	Less than 10	Less than 10	Nil	Nil
L-2	Less than 10	Less than 10	Nil	Nil
F-1:	Nil	Nil	Nil	Nil
F-2:	Nil	Nil	Nil	Nil
F-3:	Nil	Nil	Nil	Nil

3.4. Cost of weaning foods

The cost of the developed weaning food and other commercial products (F-1, F-2, and F-3) were calculated as shown in Table 7. The cost of the locally produced weaning food is suitable for the low national income in Bangladesh and cheaper than those of commercial foods.

Table 7 Cost of Locally produced weaning food and imported commercial weaning foods (BDT)

Cost/ year (900000 packets)	L-1	L-2	F-1	F-2	F-3
*Price per packet (500g/packet)	263	259	350	385	450

4. Conclusion

Highly nutritive locally produced weaning foods are produced from rice, wheat, and milk which are available in the local market, and their safety aspects were compared to imported commercial weaning foods. From the nutritional analysis of various constituents like moisture, protein, fat, ash, carbohydrate, crude fiber, and energy among four (two locally produced and three commercial) weaning foods; the locally produced weaning food has shown the most satisfactory result. The protein (an essential nutrient for rapid growth in infants) was higher in the locally produced weaning food than in imported commercial weaning foods. From the vitamins (vitamin-A and -B1) and minerals (iron and calcium) analysis of those weaning foods, locally produced weaning food has also given

the most satisfactory result. From the microbial point of view, the locally produced weaning food showed satisfactory results concerning microbial food safety. Thus, the highly nutritive low-cost locally produced weaning foods in our country are satisfactory to meet food safety requirements, ensure the rapid growth of infants, and finally, help to reduce the malnutrition situation and give extra support to nourishment for the children of Bangladesh.

Compliance with ethical standards

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Disclosure of conflict of interest

No conflict of interest to be disclosed.

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