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Development and Evaluation of Weaning Foods Using Locally Available Nutritious Fruits in Bangladesh

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ABSTRACT

Introduction: Bangladesh has one of the highest rates of malnutrition in the world although the country is endowed with agricultural produce that could be properly utilised to prepare adequate food for children. Considering this, three weaning foods were formulated using locally available cereals and nutritious fruits such as wheat, soya flour, jackfruit and mango. **Methods:** Standard procedures of Association of Official Analytical Chemists (AOAC) and American Public Health Association (APHA) were used to determine the chemical composition and microbiological analysis. Organoleptic qualities were analysed by twenty adult panelists of the Institute of Food Science and Technology, Bangladesh, using a 9-hedonic scale against a cereal based commercial brand as standard for proximate and sensory properties. **Results:** The moisture content of the developed weaning foods ranged from 2.78-3.59%, crude protein content 14.74-16.55%, fat 11.04-12.70%, ash 1.38-1.68%, crude fibre 1.04-1.52%, carbohydrate 65.83-71.09% and energy content from 445.80-465.48 kcal/100g of the foods. The formulated weaning foods A, B and C were significantly different (p<0.05) in moisture, protein, fat, carbohydrate and energy contents from the commercial brand, D. According to rat bioassay method, the prepared weaning foods C and B had the highest Protein Efficiency Ratio and Feed Efficiency Ratio than the commercial brand, D. Total bacterial counts were nil for all weaning foods. Sensory analysis revealed acceptability of all the weaning foods and preference for weaning food C that compared favorably with the standard in all the quality attributes. **Conclusion:** The formulated weaning foods are inexpensive and nutritious, and its ingredients are locally available. These foods have the potential for improving malnutrition problems facing children in Bangladesh.

Key words: Jackfruit, malnutrition, mango, soya flour, weaning food

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INTRODUCTION

Under-nutrition among children and women in Bangladesh is very common. Children 6-23 months have the highest risk of wasting, stunting and underweight (World Food Programme, 2012). Proper feeding practices during infancy and childhood are essential for attaining and maintaining proper health and nutrition (Kumar *et al.*, 2006). Inappropriate feeding practices, particularly after the age of six months when breastmilk alone is no longer sufficient to meet the increasing nutrient requirements for growth, result in high rates of childhood under-nutrition in developing countries. In Bangladesh, complementary feeding starts too early or too late, and foods that are offered are often inappropriate, leading to high rates of childhood undernutrition (Tahmeed Ahmed *et al.*, 2012). Only 43% of the children, who have crossed exclusive breastfeeding age, are fed according to the recommended infant and young child-feeding practices. For children under five, only one in two receive the minimum number of meals per day; one in three have the minimum diet diversity; and only one in five consume a minimum acceptable diet (World Food Programme, 2009)

According to Tahmeed Ahmed *et al* (2012) it is difficult to improve the micronutrient intakes of children by simply increasing the amount of complementary food currently consumed in Bangladesh. In most developing countries such as Bangladesh, commercial weaning foods of excellent quality, either imported or locally produced, are presently available but due to sophisticated processing, expensive packing, extensive promotion and huge profit margins, the price of these commercial products are generally 10-15 times higher than the common staple foods (Wurdemann & Van de Meerendok, 1994). Encouraging breastfeeding and taking proper balanced weaning foods made from locally available and cheap staple foods and processed by technology adapted to local conditions could help resolve the weaning problems facing infants and children in Bangladesh (Saeeda Raza *et al.*, 2009).

Fruits and vegetables are good sources of antioxidants, vitamins and minerals. Fruits contain various carotenoids which are a group of red, orange, and yellow pigments (Bahlol *et al.*, 2007). Mango *(Mangifera indica)* is a popular fruit in Bangladesh and is rightly called the 'king of fruits.' It ranks first in terms of area and third in production. According to the Food and Agriculture Organization (2011), Bangladesh produces 889 thousand metric tons of mangoes per annum from 170 thousand hectares of land. Mango fruit is an excellent source of vitamin-A and flavonoids like beta-carotene, alpha-carotene, and beta-cryptoxanthin. One hundred grams of fresh mango provide 765 mg or 25% of recommended daily levels of vitamin A.

Jackfruit *(Artocarpus heterophyllus)* is the largest edible fruit in the world and is the national fruit of Bangladesh. In 2010-2011, the total annual production of jackfruit was estimated to be 0.96 million metric tons from 10,652 hectares (Bangladesh Bureau of Statistics, 2012). It ranks second in production among the fruits grown in Bangladesh. Jackfruit contains 1500 mg beta-carotene per 100 gm of edible portion; beta-carotene is an antioxidant that could help prevent night blindness and promote growth (Bose, Som & Kabir, 1985)

A common cereal which today is even more in demand for its abundant health benefits is wheat. Wheat is rich in catalytic elements, mineral salts, calcium, magnesium, potassium, sulfur, chlorine, arsenic, silicon, manganese, zinc, iodide, copper, vitamin B, vitamin E and essential amino acids (Bisla, Archana & Pareek, 2012). Soy is an excellent source of dietary fibre and protein (43%) that is rich in vitamin B6 - important for building amino acids and in the formation of neurotransmitters (Henkel & Soy, 2000). As mixtures of cereals and oilseed flours can constitute an appropriate source of proteins which satisfy the criteria of Codex Alimentarius Standards for weaning/ follow up foods (World Health Organization, 2009). For these purposes, both wheat and soya flour were used in the formulated weaning foods. At present, there are no instant weaning foods commercially manufactured in Bangladesh from locally available food resources (Imtiaz, Burhanuddin & Gulzarm, 2011). In this study, three highly nutritive cereal-fruits based weaning foods were prepared for infant and young children.

METHODS

Materials

Wheat, soybean, sugar, skim milk powder, jackfruit and mango were purchased from a local market in Dhaka city, Bangladesh. Jackfruit and mango were processed within 1-2 hours of collection to inactivate the enzymatic reaction and various other physical factors effect. Soy flour was prepared using laboratory techniques. Also, a popular commercial complementary cereal food, D, served as control for assessing the nutrient levels of the formulated weaning foods. The blends were compared with RDAs of the Institute of Medicine (IOM) to ensure the local diets met the nutrient recommendations.

Processing of jackfruit

Waste from the jackfruit bulbs was removed. The blubs were then blended and the juices weighed, heated, and boiled with ascorbic acid (0.5 gm/0.45 kg of fruit) to retard browning reaction during freezing. The paste was then cooled, stored in poly bags and were refrigerated at -20°C until further use.

Processing of mango

The ripe mangoes were washed and waste removed. Fruits were peeled, stone was removed and pulp blended. The blended fruit pulp was then weighed, heated and boiled with 25% sugar added to the juice to stop enzymatic reaction during storage. The mango pulp was cooled and packed in poly bags and refrigerated at -20°C temperature until further use.

Processing of soybean

Healthy and mature soybean seeds were collected and weighed. The seeds were soaked overnight in 0.5% $NaHCO_3$ solution (1: 2.5 ratio), washed thoroughly and hull was removed. Soy seeds were boiled for 30 min to remove anti-nutrient factors such as phytic acid, tannin, trypsin inhibitor, hemagglutinin etc. The boiled seeds were strained, dried in hot air oven at 80°C, ground into powder and sieved by 100 mesh sieve.

Processing of wheat flour

Wheat flour was bought from the local market and sieved to remove foreign particles, if any. It was then stored in a cool and dry place to avoid spoilage before further use. All the materials were stored at a low temperature to prevent spoilage during the whole experimental period.

Preparation of formulated weaning foods

Three different types of weaning foods were prepared using milk powder, wheat flour, soybean flour, jackfruit, mango and many other ingredients (such as salt, sugar and oil).

The principal raw ingredients of supplementary food A were wheat, soy flour and milk powder at 25%, 20%, and 20% respectively; for supplementary food B, they were wheat, soy flour, milk powder and jackfruit pulp at 17.4%, 13%, 13.5% and 41.65% respectively; and for supplementary food C, they were wheat, soy flour, milk powder and mango at 17.4%, 13%, 13.5% and 41.65% respectively.

The preparation of the three weaning food is outlined in Figure 1.

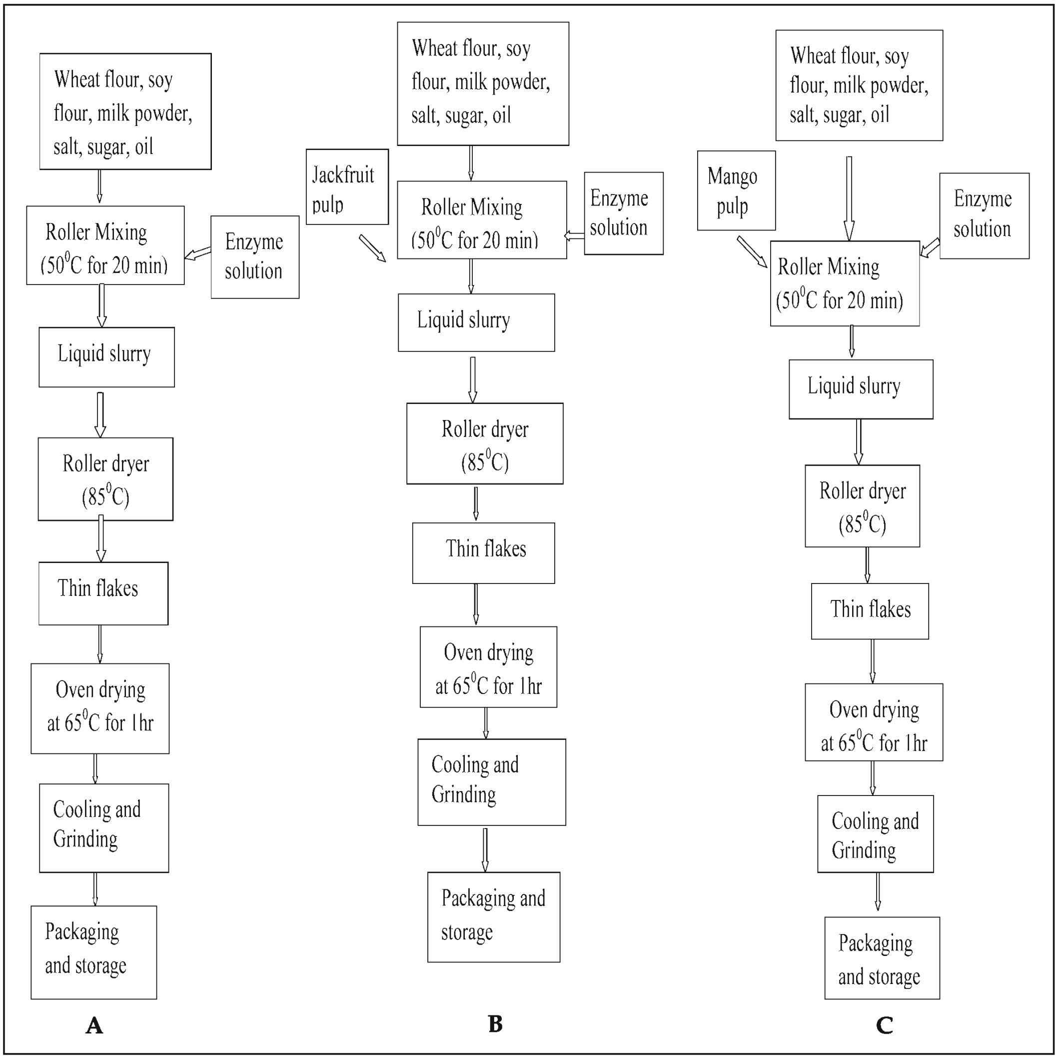

Figure 1. Preparation of three different types of weaning foods (A, B, C)

Chemical analysis of samples: Proximate analysis

The formulated weaning foods were analysed for proximate composition (moisture, crude protein, fat, ash and crude fibre) according to the standard methods (Association of Official Analytical Chemists, 2005). Crude protein was determined by multiplying the total nitrogen content by a factor of 6.25 while carbohydrate content was estimated by the difference method. It was calculated by subtracting the sum of the percentages of moisture, fat, protein and ash contents from 100% according to Association of Official Analytical Chemists (2005). Gross energy values were estimated by multiplying the values of crude protein, fat and carbohydrate by their respective physicological fuel values of 4.1, 9.3 and 4.1 respectively.

Determination of microorganisms

The formulated weaning foods were examined 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 food sample were done according to American Public Health Association (2001). Plate count method was employed for the examination of total number of viable microbes present in the sample. SPC was estimated by decimal dilution technique followed by pour plate method and spread method for fungus and yeast. Streak plate method was used to isolate the specific microorganism. Isolation and enumeration of total coliform was done by most probable number (MPN) method using MacConkey broth (Harrigen & MacCance, 1976).

Rat bioassay

To assess the nutritional quality of the formulated weaning foods and a commercial brand, a standard rat bioassay procedure was done in the animal house section of the Institute of Food Science and Technology (IFST), BCSIR, Dhaka. Long-Evan 28-30 day-old rats were fed the specific weaning foods and growth was studied. The rats were divided into four groups of 4 male rats in each cage, maintained at room temperature with 12-hour light/dark cycles. They were subjected to a 7-day acclimatisation period and individual groups were given the same amount of commercial laboratory chow diet. After 7 days, each rat group was acclimatised on an average of 55 g of different weaning foods and water *ad libitum* for 3 weeks. The control group was feed casein diet containing 45% rice powder, 15% sugar and 10-11% protein prepared in our laboratory. Food consumption, spoilage and weight gain were recorded every four days. PER was determined using the method of Champan *et al* (1959).

PER= Weight gain of test group (g) / total protein consumed (g).

FER= Gain in body weight (g)/ weaning food consumed (g)

Sensory evaluation

The three formulations were subjected to sensory evaluation. The formulations were reconstituted, coded and served warm to a sensory panel consisting of twenty adult panelists of Institute of Food Science and Technology (IFST), BCSIR, Bangladesh. A commercial weaning food, labeled D, was used as control. The formulations were rated for colour, appearance, taste, flavour and overall acceptability using a 9-point hedonic scale; where 9 represented extremely acceptable and 1 represented extremely unacceptable (Larmond, 1977).

Statistical analysis

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.

RESULTS

The proximate analyses of the three formulated and one commercial weaning food are shown in Table 1. The energy content of the prepared weaning foods ranged from 445.80 to 465.48 kcal/100g which was significantly different from the commercial weaning food, D (430.55 kcal/100g). Among the weaning foods, weaning food C had higher energy content (465.48 %) than the others. In terms of protein content, all the developed weaning foods had significantly higher content (ranging from 14.74 to 16.55%) than the commercial brand, D (12.56%); for fat content, values ranged from 11.04 to 12.70% and were significantly higher ($p<0.05$) than the commercial

Table 1. Proximate composition of the weaning foods

Weaning foods	*Proximate Composition per 100g*						
	Moisture	*Protein*	*Fat*	*Carbohydrate*	*Ash*	*Crude Fiber*	*Energy (Kcal)*
A	3.25±0.07[a]	14.74± 0.36[a]	11.04±0.17[a]	68.80±0.21[a]	1.38±0.10[a]	1.52±0.15[a]	5.80±0.09[a]
B	3.59±0.04[b]	16.55±0.33[b]	12.70±0.17[b]	65.83±0.16[b]	1.63±0.23[a]	1.18±0.17[a]	455.63±0.34[b]
C	2.78±0.03[c]	15.67±0.11[ab]	11.77±0.11[c]	71.09±0.24[c]	1.53±0.25[a]	1.04±0.18[a]	465.48±0.22[c]
D (as control)	2.33±0.12[d]	12.56±0.26[c]	9.14±0.12[d]	71.72±0.15[c]	3.21±0.10[b]	0.99±0.02[a]	430.55 ± 0.32[d]

Mean values by different superscripts within columns are significantly different at p<0.05.

Table 2. Micronutrient composition of the weaning foods

Weaning foods	*Composition per 100g*			
	Vitamin A (µg)	*Iron(mg)*	*Ca(mg)*	*Zn(mg)*
A	200.38 ± 0 .16[a]	7.56 ± 0.21[a]	413.55 ± 0.32[a]	3.50 ± 0.12[a]
B	220.65 ± 0.27[b]	8.04 ± 0.17[a]	450.63 ± 0.36[b]	4.26 ± 0.33[a]
C	250.85 ± 0.17[c]	8.22± 0.49[a]	438.37 ± 0.46[c]	3.78 ± 0.47[a]
D(as control)	270.89 ± 0.38[d]	7.57 ± 0.38[a]	471.00 ± 0.22[d]	3.52 ± 0.44[a]

Mean values by different superscripts within columns are significantly different at p<0.05.

weaning food, D (9.14%); for ash content, the values ranged from 1.38 to 1.63% and were significantly lower than the commercial food, D (3.21%); for moisture content, the values ranged from 2.78 to 3.59% and were significantly different from the commercial brand, D (2.33%); for crude fibre, the values ranged from 1.04% to 1.52% and were significantly different from commercial weaning food D (0.99%). Formulated weaning foods A and B had carbohydrate content of 68.80% and 65.83%, respectively which were significantly different from each other and also from the formulated weaning food, C (71.09%) and the commercial weaning food, D (71.72%).

The results of the micronutrient analysis are shown in Table 2. The results revealed that commercial brand, D had a vitamin A content of 270.89 μg/100g which was significantly (p <0.05) higher than the formulated weaning foods A, B and C (200.38-250.85 μg/100g); for calcium content, the values for A, B & C were 413.55, 450.63 and 438.37 mg/100g which were significantly lower than the commercial brand D (471.00m g/100g; for iron content of A, B, C and D, the values were 7.56, 8.04, 8.22 and 7.57 mg/100g respectively; while for zinc content, the values for A, B, C and, D were 3.50, 4.26, 3.78 and 3.52 mg/100g respectively. In terms of iron and zinc contents, all weaning foods were non-significantly different from each other (Table 2).

The comparative microbiological load values are shown in Table 3. The results showed that total viable count, Salmonella, coliform, yeast and mold were absent in all the formulated and commercial weaning foods.

The PER and FER assessment by rat bioassay are shown in Table 4. The results revealed that the formulated weaning foods had PER values ranging from 2.00 to 2.11 which were higher than the commercial brand, D (1.96) and the casein diet (1.71). The FER were 0.29, 0.34, and 0.33 for the

Table 3. Comparative microbiological load of weaning foods

Weaning foods	*Total viable count (CFU/g)*	*Yeast and mold count (CFU/g)*	*Total Coliform count (CFU/g)*	*Salmonella/g*
A	Less than 10	Less than 10	Nil	Nil
B	Nil	Nil	Nil	Nil
C	Nil	Nil	Nil	Nil
D(as control)	Nil	Nil	Nil	Nil

Table 4. Food intake, protein intake and body weight gain of rats, for the assessment of PER and FER

Weaning foods	*Food intake (g)*	*Protein intake (g)*	*Weight gain up (g)*	*PER*	*FER*
Casein diet	545.6	53.05	90.65	1.71	0.17
A	620.33	91.43	182.89	2.00	0.29
B	615.45	101.86	210.56	2.10	0.34
C	635.65	99.61	210.33	2.11	0.33
D(as control)	630.52	79.19	155.25	1.96	0.24

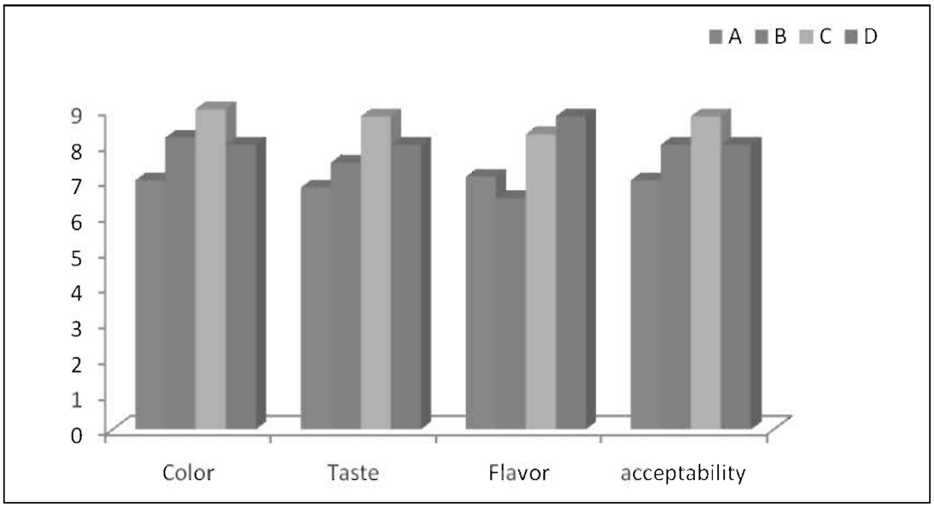

Figure 2. Sensory evaluation of the formulated weaning foods (A,B,C) and commercial brand,(D).

formulated weaning foods A, B and C respectively and 0.17 for casein diet and 0.24 for commercial brand, D.

Three developed weaning foods and the commercial brand were evaluated organoleptically for colour, taste, flavour and overall acceptability by 20 adult panelists (Figure 2). Weaning food C had the maximum score for colour (9.0) and taste (8.8). The minimum score for taste (6.8) was recorded in weaning food, A. In terms of flavour, weaning food B had the lowest score (6.5) whereas weaning food D had the highest score for flavour (8.8). With due respect to overall acceptability of weaning foods, the maximum score was obtained by weaning food C (8.8) and minimum score was obtained by weaning food A (7.0). These results indicate that the prepared weaning food C was preferable, compared to other weaning foods.

DISCUSSION

The quality of fruit-based infant foods is of considerable importance, since babies may be obtaining all their nutrients from a small number of foods and over-processing of infant foods may affect their nutritional status (Maite, Augustin & Mar, 2002). Different baby food formulas have been prepared from different varieties of cereals and fruits which were found to be acceptable by children such as dehydrated rice powder and skim milk. They were used in the preparation of low cost weaning food by Satter *et al.* (2013) while soya bean flour and different fruit purees were used by Segura *et al.* (1988). A study in Bangladesh showed that the amount of energy from complementary foods offered to infants was about 74% of the recommended amount (Kimmons *et al*, 2005). The intakes of vitamin A, vitamin D, iron and zinc from complementary food were much lower than the recommended nutrient intake for children aged 6-12 months (Tahmeed Ahmed *et al.*, 2012). The chemical analysis of the formulated weaning foods revealed that protein; fat, carbohydrate, calcium, zinc, iron and energy met the normal required standard for weaning foods according to FAO/ WHO Codex Alimen-tarius Standards and also met the RDA for 7-12 months recommended by the Institute of Medicine (IOM, 2005). This may be the result of addition of fruits in the weaning foods which increased their nutritional values. For all the weaning foods, both prepared and commercial, the energy density per 100 g of the dry food was higher than the minimum energy (400.00 kcal/100 g) recommended in the Codex Alimentarius Standards for weaning /follow up foods (World Health Organization 2009).

According to Codex Alimentarius Standards for weaning / follow up foods, the energy derived from protein should range from 6% to 15% and the energy from fat at least 20% (WHO, 2009). The energy contents of the formulated weaning foods A, B and C derived from protein were 13.56%, 14.89% and 13.80% respectively and from fat were 23.03%, 25.92% and 23.52% respectively which met the Codex Alimentarius Standards. The commercial brand, D also met the Codex Alimentarius Standards as 11.96% of energy was derived from protein and 19.74% from fat.

According to the Food and Nutrition Board, Institute of Medicine (2005), the recom-mended daily allowances (RDA) for energy, carbohydrate, protein, fat, vitamin A , Ca, Fe and Zinc for 7–12 month-old infants are 743 kcal, 95 g ,11 g, 30 g ,500 μg, 270 mg ,11 mg and 3.0 mg respectively. A 100 g portion of the three prepared weaning foods assayed in this study could meet the daily requirements (% of RDA) of energy (60.0-62.65%), carbohydrate (69.29-74.83%), protein (134.0-150.45%), fat (36.8-42.33%), vitamin A (40.08-50.17%), Ca (153.17-166.9%), Fe (68.73-74.73%) and zinc (116.67-142.0%). For the commercial weaning food, a 100 g portion of the food could meet the daily requirements (% of RDA) of energy (57.95%), carbohydrate (75.49%), protein (114.18%), fat (30.74%), vitamin A (54.18%), Ca (174.44%), Fe (68.82%) and zinc (117.33%).

Microbial contamination levels were found to be nil (Table 3) in all the weaning foods, both formulated and commercial. These results indicate that the weaning foods were prepared using good quality raw materials under safe and hygienic conditions in the laboratory. The micro-biological results are in agreement with Bahlol *et al.* (2007) and Wadud *et al.* (2004).

Formulated weaning food C had the highest PER, whereas B had the highest FER compared to the other developed and commercial weaning foods (Table 4). Sensory evaluation of the formulated weaning foods compared to commercial product as control (Figure 2) indicated that the developed weaning food C was mostly preferred in terms of taste, colour and overall acceptability over other formulated weaning foods and control.

CONCLUSION

Three highly nutritive weaning foods were prepared in our laboratory using commonly consumed, locally available low cost food materials in Bangladesh. One of the weaning foods (C) offers the potential for use both at home and commercial levels as its nutritional quality and acceptability are higher than the other formulated weaning foods and commercial food, D. There is improvement in the nutrient quality of the formulated complementary foods with good acceptability. Moreover, it is cheap and the ingredients are easily available compared to the commercial brand used in our country. Weaning food C can be improved with the ultimate goal of contributing to the reduction of malnutrition among children in Bangladesh.

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