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# Studies on the Development and Evaluation of Cereal Based Highly Nutritive Supplementary Food for Young Children

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**ABSTRACT:** Early weaning practices are one of the most important causes of malnutrition of children which ultimately increase the chance of infant morbidity and mortality. The present study was carried out to develop cereal based supplementary food from indigenous raw materials for young children and to evaluate nutritional quality. The formulated baby food was produced from soy flour and wheat flour and was analyzed for their chemical, functional, microbiological and sensory qualities using standard methods. Moisture, Ash, Protein, Fat and Crude Fiber content was found 2.78%, 1.88%, 11.91%, 8.61% and 0.58% respectively, which was able to meet the young children's recommended daily allowances. The values of functional properties such as water absorption capacity 156.35%, bulk density 0.50%, solubility 47.913%, swelling power 12.16% and viscosity 34.4% were found. The microbial analysis was done to see the acceptability of the product and the result was good from the microbiological point of view. The main metal content of the formulated baby food such as sodium, potassium, iron, magnesium, zinc and calcium were 224.4, 280, 8.0, 5.1 and 453.4 (mg/100g) respectively and Vitamin A was found 200µg/100gm. The heavy metal content of the formulated weaning food was found below the detectable level. On the basis of results pertaining to chemical and functional properties of the formulated baby food, the nutrient content was sufficient to meet the infant's basic need. Therefore, the food may support us to maintain a healthier life at a cheap rate which is locally available and help to reduce malnutrition situation in Bangladesh.

**KEYWORDS:** Cereal; Supplementary food; Formulated baby food; Nutritional quality; Microbiological and sensory qualities

## 1 INTRODUCTION

Under nutrition is one of the major problems confronting infants and young children in the developing countries. However, at the age of six months and above when the child's birth weight is expected to have doubled, breast milk is no longer sufficient to meet the nutritional needs of the growing infant. Protein energy malnutrition and micronutrient under-nutrition occur together. Millions of children and women suffer from one or more forms of malnutrition including low birth weight, wasting, stunting, underweight, Vitamin A deficiencies, iodine deficiency disorders and anemia. Although recent progress has been made in reducing the incidence of poverty, malnutrition still remains one of the most serious problems in Bangladesh and responsible, directly or indirectly, for about one half of the 343,000 deaths that occur annually among children under five years in Bangladesh. About three-quarters of these deaths, which are often associated with inappropriate feeding practices, occur during the first year of life. Most children between the age 4 months and 2 to 3 years suffer from malnutrition. The reasons behind this fact are generally low incomes, poor sentimental conditions and lack of education (BDHS, 2007 and General Economic Division, Planning Commission, GOB, 2007).

Weaning of a child is a gradual process by which an infant is introduced to adult diet. Weaning food is a special formulation, which is a supplement to the breast milk. The composition will be as close as possible to breast milk except for higher calories and protein's values. Breast milk from a well-nourished mother is inadequate to meet nutritional needs of an infant for the first three months of life; therefore, there is need for supplement or weaning food (Unicef, 1998). In view of this nutritional problem, several strategies have been used to formulate baby food (Lalude & Fashakin, 2006; Ijarotimi & Bakare, 2006), through a combination of locally available foods that complement each other in such a way that provide the recommended daily allowance for infants. Guidelines state that an ideal formulated baby food must be nutrient dense, easily digestible, of suitable consistency and affordable to the target market (FAO/WHO, 1989). 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. Despite all these efforts, it is evident that the formulated supplementary foods currently available are not accessible to many low income mothers due to the high cost of production and non-availability of the food materials used in the formulation (Agbede & Aletor, 2003).

Infant feeding and rearing practices have a major effect on short term and long-term nutritional status of children, as most of under nutrition is associated with faltering practices that occur in weaning period. Faulty feeding practices as well as lack of suitable weaning foods are responsible for under nutrition. Only 42% of infants aged less than six months are exclusively breastfed and almost one-third (29%) of children aged 6-9 months do not receive any solid or semi-solid foods. Complementary foods given to infants and young children in Bangladesh are often nutritionally inadequate and unsafe, leading to malnutrition. Foods from animal sources such as fish, meat and egg are expensive and not commonly given to children. Nutritious complementary foods are therefore introduced - also known as weaning foods - which typically covers the period from six to twenty four months of age in most developing countries. Weaning foods currently manufactured and imported from abroad used to meet the needs of growing children are too costly to be afforded by the majority of the target population in our country. Simpler methods of making weaning foods using diverse and locally available raw materials which could be made available at low cost and able to meet infant's nutritional needs are necessary. The formulated food should have characteristics according to nutritional needs, appropriate textures and viscosity, and appropriate forms (liquid, semisolid, solid) to support mental and physical development.

At present, there are no formulated baby foods manufactured in Bangladesh from locally available food resources. Only a small sector of the community uses imported baby foods. Formulated baby food produced by sophisticated technologies is costly and is not within the reach of rural dwellers and low income earners in the urban cities. In recent years, consumers have become more health conscious in their food choices but have less time to prepare healthful meals. As a result the market demand for "minimally processed" or "lightly processed" foods has rapidly increased. The aim of this study was to develop a cereal based highly nutritive supplementary food for young children of Bangladesh by using available resources and cheap technology. And also to determine the acceptability and to identify microorganisms that were associated with the formulated baby food.

## 2 Materials and Methods

### 2.1 Preparation of Highly Cereal Based Instant Supplementary Baby Food

A highly nutritive cereal based instant supplementary baby food has been prepared from wheat flour and soy flour at cereal technology section, IFST, BCSIR, Dhaka. Imported foreign commercial baby foods like: Wheat & Milk' (Cerelac 1), and mango, milk & rice' (Cerelac 2), were taken to compare with the formulated baby food. Wheat flour (Maida), Milk Powder, Processed Mango pulps and Processed Soybean flour were used for the preparation of formulated baby food in our laboratory and these ingredients (Maida, Milk powder, Soybean & Mango) were collected from New Market Kacha Bazar, Dhaka. Mango was processed within 1-2 hours of collection to inactivate the enzymatic reaction and various other physical factors effect. Soy bean was processed and prepared by using the laboratory techniques. Wheat flour was also processed before use. Wheat flour was sieving it with a siever to remove foreign particles if any and separate flour for making product. Now store it at cool place to avoid spoilage and used it to make product in future. All the materials were stored at low temperature for being good during the whole experiment time. The ripe mangoes were taken and wastes were removed. The fruit peels were removed and then pulps were blended. The blended fruit pulps were then weighed, heated and when boiled, 25% sugar of weighed juice were added to stop enzymatic reaction during storage. The paste were then cooled and packed in poly bags. These bags were then refrigerated at $4^0$C temperature. The healthy and mature soybeans were selected and collected. Soybeans were soaked with 0.5% NaOH solution and after overnight soaking soybean were washed thoroughly to remove hulls. Then the seed were boiled for 30 min to remove the anti-nutrient factors and then strained and dried in hot air oven at $80^0$C. The dried seeds are then grinded into powder and sieved.

### 2.2 Nutrient Analysis

Nutrient analysis was done for prepared sample and for all collected imported samples. Moisture content of collected samples was determined by drying the samples at $105^0$ C in a drying oven till a constant weight was attained (AOAC, 1995). Ash content was determined in triplicate using a muffle furnace at 600±2.00°C for 8 h by AOAC method (AOAC, 2000). Total lipid content was also determined by the method of AOAC (2005). Protein content was determined by the AOAC (2005) Kjeldahl method by first determining the percent nitrogen content and then converted to % crude protein by multiplying with the factor 6.25. Crude fiber was determined by Acid-Alkali Hydrolysis as followed AOAC (2005). Total sugar of the prepared and imported sample was determined by Phenol Sulfuric acid method (Dubois *et al.*, 1956, Krishnaveni *et al.*, 1984). ). Available carbohydrate content was determined by difference, i.e. by subtracting the sum of the values of moisture, ash, protein and fat from 100 (per 100gm) (AOAC, 2005). Lactose content of milk powder was determined by Gravimetric Method using Fehling's Solution (Official Methods of Analysis, 1998**).** Estimation of milk fat procedure is different from cereal fat estimation procedure. Milk fat content was determined using a Teichert type butyrometer (Molnar and Agh, 1970. Gluten content of the cereal flour was determined by the methods as described by the American Association of Cereal Chemists (AACC, 2000). The energy content of the baby food samples were determined by calculating the amount of protein, fat and carbohydrate of respective food items and by using the following equation (Edeoga, *et al.*).

$$\text{Energy} = (\text{Protein} \times 4.1) + (\text{Fat} \times 9.3) + (\text{Carbohydrate} \times 4.1).$$

### 2.3 Functional Properties Analysis

Water binding capacity of baby food was analysed by adding 2 gm of sample along with 4 gm of distilled water in a centrifuge tube. The tube was shaken for I hour and then centrifuge for 15minutes at 2200 rpm. The supernatant was decanted and the percent of water gained was determined (Beuchat 1977). Water absorption capacity of samples was determined by the methods as described by Sathe and Salunkhe (1981). Bulk Density, Solubility and Swelling Power were determined by the methods as reported by Oladele and Ania, 2007). Viscosity of supplementary baby food was measured by a rapid Visco Analyzer, using slurries with 10% solids at $350^C$ and expressed in meter Meter×Pascal/ second (AACC, 2000).

### 2.4 Vitamin and Mineral Analysis

#### 2.4.1 Determination of Vitamin-A

Vitamin A found in animals foods as retinol and in plant foods as all-trans-beta-carotene. Vitamin A (Retinol) was determined by high performance liquid chromatography with UV-detection after saponification and extraction (Horwitz W and GW Latimer, 2001). Standards and samples are saponified in basic ethanol-water solution, neutralized, and diluted. This process converts fats to fatty acids, and retinyl esters to retinol and the corresponding fatty acids. Retinol is quantified in an HPLC system, using UV detection at 326 nm. Vitamin A content was then calculated by comparison of peak heights or peak areas of retinol in test samples with those of standards.

### 2.5 Determination Mineral and Heavy Metal Content by AAS

Mineral and heavy metal content of the tested baby foods were analyzed with the use of Flame emission atomic Absorption Spectrophotometer (Model no. Jencons, PEP7) at 589 nm and 769 nm of wavelength respectively (Jackson, 1967 and Gian Carlo *et al.* 2009). 10.0 gm of dry sample (dried at $200^0$C) was taken in a porcelain dish and then placed into a muffle furnace and heated at $100^0$C, $200^0$C, $300^0$C, $500^0$C for 1 hour each and $600^0$C for several hours. After burning, ashes were taken to 250 ml beaker and 50 ml of deionized distilled water and 15 ml concentrated nitric acid was added. Then the samples were returned to a hot plate with continued heating, additional acid (if necessary) was also added until digestion was completed. Then the sample was filtered into a 250 ml volumetric flask and each sample was made up to the mark with deionized water. Standard stock solution of 100 ppm was prepared for every tested mineral and metal. These solutions were prepared from their pure metal turning and pure compound using nitric acid. Working standard and blanks were acidified to the same extent as samples. Standard solution were preserved in clean polyethylene bottle and kept in refrigerator. These standard stock solutions were further used to prepare standard metal ion solution by suitably diluted with deionized water. The atomic absorption instrument was set up and flame condition and absorbance were optimized for analyte. Then blanks, standards, and samples were aspirated into a flame in AAS. Mineral and heavy metals content were statistically analyzed by constructing a calibration curve (Gian Carlo *et al.* 2009).

### 2.6 SENSORY EVALUATION OF FORMULATED AND IMPORTED BABY FOOD

The sensory properties of products is usually evaluated and ranked on the basis of scores given by the panel of judges to the product. They like or dislike the various parameters. The food supplemented with wheat flour, soy flour, milk powder and mango were subjected to sensory evaluation for color, flavor, taste, texture and overall acceptability by a panel of trained judges for acceptance or rejection. Before analysis the supplementary food was mixed with warm water in a ratio of 1:3 and stirred slowly and served hot. Samples were presented in succession and panelists were asked to rate evaluation variables according to 9- point Hedonic scale as described by Larmond (1977). The 9-point Hedonic scale was used, where the lowest point 1 = extremely dislike and the highest point 9 = extremely like. The mean squares and the result of the analysis of variance revealed that sensory scores assigned by judges on color, flavor, taste, texture and overall acceptability were found statistically significant.

### 2.7 MICROBIOLOGICAL ANALYSIS

Microbial examinations of infant formulas were performed to assess Bacterial, Fungal and Yeast load under laboratory condition. Standard plate count, fungal count and enumeration of total Coliform, E. coli and *Staphylococcus aureus ssp* of those baby food samples were also examined. All media and equipment were sterilized by steam Sterilization at 15 psi for 20 minutes at $121^0$C in an autoclave. For analysis 10 gm of each sample was aseptically weighted and diluted to 1:10 (10 gm in 90ml) with sterilized distilled water and mixed well. Serial dilutions were prepared and spread plate technique was used on appropriate selective media. Plate count method was employed for the examination of total number of viable microbes present in fish sample. In this method only plates having 30-300 colonies were counted. Standard Plate Count (SPC) was estimated by decimal dilution technique followed by Pour Plate Method and Spread Plate Method for Fungus. Streak Plate method was used to isolate the specific microorganism. In the Pour Plate Method, 0.1 ml and 1ml samples were pipette onto sterilized Petri plates. Sterilized agar medium was cooled to about $45^0$C and was poured on the plates. The media was mixed well by a gentle swirling motion. The Petri plates were then allowed to solidify. The plates were incubated at the required temperature for 24-72 hours. In this study for each sample there were 2 Petri plates for 0.1 ml and other 2 for 1ml (Badau *et al*., 1999, Badau *et al*., 2001). For Spread Plate Method approximately 15 ml of previously autoclaved medium was poured in a sterilized Petri plate and was kept at room temperature until the agar was solidified. In Potato Dextrose Agar (PDA) plate 0.2 ml sample was dropped onto a solidified agar plate then the sample was spread on the agar plate with the help of sterilized bent glass rod (spreader). By this method Yeast and Mould counts were determined (Mosupye et al. 1999, Mudgil et al. 2004). In the Streak Plate Method, the media along with microbes were transferred with a narrow headed loop from lactose broth conical flask and from LST tube and dropped with this loop; the streak was done on to the agar plate. The plate was then incubated at the required temperature ($37^0$C) for 24 to 72 hours. All steps of this media were done under laminar airflow. Isolation and enumeration of total Coliform were performed by MPN method. The Most Probable Number (MPN) method using MacConkey broth (Harrigen and MacCance, 1976) is a statistical, multi-step assay consisting of presumptive, confirmed and completed phases. In the assay, serial dilutions of a sample are inoculated into broth media. From the gas positive (fermentation of lactose) tubes, the other 2 phases of the number of organisms can be estimated from statistical tables. Typically only the first 2 phases were performed in Coliform analysis for *E.coli* **(**Speck, M. L. 1976). Staphylococcus aureus of the food sample was examined according to APHA-1999.

## 3 RESULTS

### 3.1 CHEMICAL COMPOSITION OF RAW MATERIALS AND BABY FOODS

The data for chemical composition i.e. moisture, ash, crude protein, crude fat, crude fiber, crude carbohydrate and energy have been presented in the following manner. All the analysis was performed in triplicate and the values are used in average.

### 3.2 SHELF LIFE OF FORMULATED BABY FOOD

The shelf life of baby food was studied for three months at ambient conditions. No significant changes in ash, crude protein, crude fat, crude carbohydrate, sugar except moisture were observed. All the analysis was performed in triplicate and the values were given in average (Table 2). The moisture content of the formulated baby food was significantly increased from 2.78 to 3.69 g/100g and carbohydrate also increased from 74.39 to 76.55g/100g. The ash, fat, sugar, dietary fiber and energy value slowly decreased during storage period.

### 3.3 FUNCTIONAL PROPERTIES OF FORMULATED BABY FOOD

The functional properties of formulated baby food such as water absorption capacity (WAC), bulk density (BD), water binding capacity (WBC), solubility, swelling power and viscosity were analyzed and the results are given in Table 3.

The formulated baby food show the following functional properties such as water absorption capacity, bulk density, water binding capacity, solubility, swelling power and viscosity were 156.35(ml/g), 0.50(g/ml$^{-1}$), 480.13(g/100g), 47.913(%), 12.16(gg$^{-1}$) and 34.4 (mp/s) respectively.

### 3.4 MICRONUTRIENT ANALYSIS OF FORMULATED BABY FOOD

The micronutrient content of formulated baby food such as vitamin, mineral and trace metal e.g. vitamin A, beta carotene, sodium, potassium, iron, magnesium, chromium, cadmium, nickel were analyzed and the result are given in Table 4.

The results indicate that the vitamin A content of formulated baby food was 200μg and the sodium, potassium, iron, magnesium, chromium, cadmium, nickel, zinc, calcium content were 224.4, 280, 8, 5.1, 1.64, 0.1, 7.96, 10 and 453.4 (mg/100g) respectively. Cerelac-1 and Cerelac-2 contain the same amount of Vitamin A such as 270μg. The mineral content of Cerelac-1 such as sodium, potassium, iron, calcium and zinc was 100, 450, 7.5, 350 and 3 mg/100g respectively and Cerelac-2 contain 220, 510, 7.5, 540 and 3 mg/100g respectively.

### 3.5 MICROBIOLOGICAL ANALYSIS OF FORMULATED BABY FOOD

The distribution of micro-organisms and their amount of occurrence in the formulated baby food during storage period for three months (APHA-1999) were shown in Table 5. Comparative microbiological load of formulated baby foods has shown in table for three months. Microbial findings of Standard Plate count, total fungus count, total Coliform count and presence of *Staphylococcus aureus* per gram were absolutely nil/g or <10 cfu/gm in the baby foods analyzed, but the fungus count may be increase due to increasing moisture after few days which ranges from <10 to 200 cfu/gm .

### 3.6 SENSORY EVALUATION OF FORMULATED AND COMMERCIAL BABY FOOD

The results of the sensory evaluation performed on reconstituted weaning food paste made from warm water and baby food powder were shown in Figure-1. It was served to 10 members of testing panel who were asked to mark the paste on the basis of color, flavor, taste, texture and overall acceptability using a point hedonic scale where 1= dislike extremely and 9= like extremely as reported by Larmond .

The sensory parameter of the formulated baby food show that the average score of color, flavor, taste, texture and overall acceptability were 8.33, 7.56, 7.78, 7.89, 7.44 respectively. The sensory score for Cerelac-2 were 8, 7.2, 8.2, 7.5, and 7.45 for color, flavor, taste, texture and overall acceptability respectively.

## 4 DISCUSSION

The weaning period is the most critical phase of infant's life. During this period mother's milk is not generally adequate to cover the nutritional requirements and support body growth. Weaning foods are generally introduced between the ages of six months to three years old as breastfeeding is discontinued. While breastfed infants are often able to maintain adequate growth through their sixth month, additional nutrients are required to complement or, in some cases, replace breastfeeding completely. A weaning food should be accessible to the child and should be adequate in protein, fat, carbohydrates, vitamins and minerals to alleviate protein-energy malnutrition. It is an essential element in the care of young children especially in the developing countries where malnutrition is prevalent [World Bank, 2005 study was performed as a result of the high price of commercial baby foods which cannot be afforded by many of low income families. Commercial baby food was also unable to meet infant's nutritional requirement. To meet these requirements, we have tried to develop a highly nutritive supplementary baby food enriched with locally available indigenous raw materials such as mango, wheat flour, soy flour and milk powder in our laboratory and analyzed its nutritional composition and hygienic aspect.

In the nutritional point of view the supplementary baby food prepared in our laboratory was compared with the commercial baby foods available in Bangladesh. The carbohydrates content of the formulated baby food was 74.39g/100g, whereas Cerelac 1 contains 67.75 g/100g and cerelac 2 contain 71.7g/100g. The RDA of carbohydrate for infant is 95g/day (IOM, 2005). So the formulated food had higher carbohydrate content than cerelac and supply 71.32% recommended carbohydrate for infant. The protein content (g/100 g dry weight) in the formulated food was 11.91 g/100g. The high content of protein in the commercial foods Cerelac-1 was 15g/100g and cerelac-2 was 12.5g/100g, where the RDA of protein is 11g/day (IOM, 2005). According to the Indian Council of Medical Research (1981), the recommended optimal protein - calorie requirement for pre-schoolers is 7.1% in total mixed diet. The result indicated that the formulated baby food had lower protein content than Cerelac-1 but it was adequate in protein content for weaning purposes because it supply 108% protein of RDA for infant. The formulated baby food contained comparatively lower amount of fats than the commercial baby foods. Food sample with high fat content is more liable to spoilage than one with a lower fat content (Oduro *et al*., 2007). The ash content of the product gives an idea of the mineral content, although formulated baby food had low ash contents (1.88g/100g) than the commercial baby food (cerelac-1 contains 2.45g/100g and cerelac-2 contains 3.2 g/100g). Fiber containing food is better for maintaining good health but, infants do not get benefit from a high fiber intake and therefore fiber levels must be controlled in children's foods. In this study, the formulated baby food contained the lowest amount of fiber compared to the commercial baby food because soy flour was used as a major component of the food that contained low fiber and mango contain the soluble dietary fiber which was good for child health. The percent crude fiber of the formulated baby food was 0.58%. This value is comparable to the value of 1-2.3% which is found in Commercial baby food. Fiber is an important dietary component in preventing overweight, constipation, cardiovascular disease, and diabetes and colon cancer. However, high dietary fiber content has been reported to impair protein and mineral digestion and absorption in human subjects (Whitney EN, Hamilton EMN, Rolfes SR, 1990). The percent of protein derived calorie ranged from 11.96 to 14.25(%) in commercial baby food, whereas formulated baby food was 10.98(%). This implies that the products would supply the needed energy to meet infants' growth demands. The total energy content of the infant's diet must be maintained with controlled limits. An insufficient energy intake could lead to failure to thrive, whereas an energy intake in excess of requirements may lead to obesity. The "energy density" (amount of energy in a given quantity of food) is, therefore important. The energy content of the formulated weaning foods was 433.9 kcal/100 g. For the commercial baby food such as Cerelac-1 and Cerelac-2, the energy densities were 421 and 418 kcal/100g respectively. The RDA of energy for infant is 880kcal/day (IOM, 2005). The energy densities observed in this study for formulated baby food was slightly high than commercial baby foods and supply 58.27% calorie of RDA to meet the energy needs of the infant.

According to Singh (2001), water absorption capacity (WAC) is the ability of a product to associate with water under a condition where water is limiting, while water binding capacity (WBC) connotes water that is retained by the protein after processing. The water absorption capacity of the formulated baby food was 156.35 (g/100g) and the water binding capacity was 480 (g/100g). The significance of a lower WAC and WBC of the supplementary diets is that it will have lower water absorption and binding capacity which is desirable for making thinner gruels with high caloric density per unit volume (Elkahalifa *et al*., 2005). The bulk densities of the formulation was within range (0.49-0.63g/cm$^3$) reported for yam (Hsu *et al*., 2003). Bulk density is a measure of heaviness of flour (Adejuyitan *et al*., 2009) and an important parameter that determines the suitability of flours for the ease of packaging and transportation of particulate foods (Shittu *et al*., 2005) as well as for infant formulations. According to Nelson-Quartey *et al*. (2007), low bulk density flours are desirable in infant food preparation. The low bulk density of the formulated baby food therefore suggests they could be good for infant health. Solubility is an index of protein functionality such as denaturation and its potential applications. The solubility of formulated baby food was 47.91 % and swelling power was 12.16gg$^{-1}$. According to WHO (2003), appropriate complementary diet is one which produce a gruel or porridge that is neither too thick for the infant to consume nor so thin that energy and nutrient density are reduced. In this study the formulated baby food had moderate solubility and low swelling power, which make it good as a weaning food. The viscosity of the formulated baby food was 34.4mp/s. Low viscosity weaning diet with a high nutrient content is a desirable characteristic in weaning foods (Ariahu *et al*., 1999). Thus it can be inferred that the functional properties of the formulated diet will provide an appropriate complementary diet in terms of texture, dietary bulk and caloric density.

Sodium concentration was highest in the formulated baby food (224.4mg/100 g) and lowest in the commercial baby food (cerelac 1 contain 100 mg/100 g & cerelac 2 contain 220 mg/100 g). This was evident in the commercial weaning foods analyzed in this study; the Na concentrations in the cerelac were within the range (96.78–411.32 mg/100g) specified in the Codex Alimentarius standard for weaning foods (FAO/WHO, 1994). Potassium, just like Na, is an electrolyte essential in the homeostatic balance of body fluids. The concentration of K in Cerelac-1 was 450 and cerelac-2 was 550mg/100g, whereas 280mg/100g in the formulated baby Food. The RDA of K for infant is 700mg/day (IOM, 2005) which was higher than the formulated baby food. So the K content will be fortified in future by adding premix. Magnesium is a micronutrient used for bone mineralization, teeth maintenance, building up of proteins, enzyme activities, normal muscular contractions and transmission of nerve impulses. Magnesium concentration was generally lower in the formulated baby food than the commercial weaning foods. Concentration of Mg in the formulated weaning foods was 5.1mg/100g. An iron concentration in the formulated baby food was 8.0 mg/100 g; while in the commercial foods (cerelac-1 & 2), the concentration was 7.5mg/100 g. The RDA of iron for infant is 10mg/100g (IOM, 2005). Thus the high iron content of formulated baby food compared to commercial baby food can meet the 80% RDA of iron for infant. Calcium is an essential micronutrient in infants and young children for building bones and teeth, functioning of muscles and nerves, blood clotting and for immune defense (Whitney *et al.* 1990). The concentration of Ca was highest (carelac-1 contain 350 and cerelac-2 contain 540mg/100 g) in the commercial weaning products and was moderate (453.4mg)/100 g) in the formulated weaning foods. According to the Codex Alimentary standards (FAO/WHO, 1994) Ca concentration in weaning foods should not be less than 435.51 mg/100 g of the dry food. So the formulated baby food fulfills 75% RDA of calcium for infants Zn content in the commercial products is 3.0 mg/100 g in Cerelac 1 & 2 and 10mg/100g in the formulated baby food. Results of this study indicate that the formulated baby foods were generally high sources of Zn compared to the commercial milk based products. The result revealed that the trace metal such as cadmium, cupper, chromium and lead content of the formulated baby food were 0.1mg/100g, 4.73mg/100g, 1.64mg/100g and bdl (below detectable level). This is very good results from the biological point of view.

Accelerated storage stability tests were used to estimate the shelf-life of the products developed. The shelf life of formulated baby foods was studied for three months at ambient conditions. No significant change in protein, fat, carbohydrate, ash, dietary fiber and energy values were observed except moisture (Table 2). Moisture content was slowly increased during storage period from 2.78 to 3.88 (g/100g). High moisture content in foods has been shown to encourage microbial growth (Temple VJ, 1996). The fungus count increased during storage period due to high moisture. The overall bacteriological status of the formulated baby food was observed to be satisfactory. It was found that the formulated baby food contained <10 cfu/gm microbial load in the sample which is in a normal range. The total Fungal Counts was <10 (cfu/gm) at 1st month, which was become $1\times10^2$ (cfu/gm) at 2nd month and ($2\times10^2$ cfu/gm) at 3rd month due to moisture retention during storage period. A food product for consumption should have microbial count below $1\times 10^5$ cfu/ml. The formulated food sample was found to contain no Coliform Count. However, yeasts and moulds, coliform group and *Staphylococcus aureus* were found to be totally absent in the formulated baby food. The low counts of the examined formulated baby food indicated adequate thermal process, good quality of raw materials and as a result of the good different processing conditions under which the production of formulas was carried out. The microbiological results suggested that the formulated baby foods are suitable to be submitted for sensory evaluation by babies and adult panelists.

The mango flavor of the formulated baby food made the product more acceptable than the commercial baby food (cerelac). Overall acceptability scores for the formulated food and the commercial food were almost similar. Members also commented on additional attributes of the foods such as the child's preference or after-taste discomforts, and suggested price and purchase intent. It has been shown that functional properties would produce a more physically balanced and acceptable products which will be cheaper and readily available. Further studies are necessary to determine the longevity of the product and economics of large scale production.

***Table 1: Chemical Composition of Raw Materials and Baby Foods***

| Ingredients / Foods | Moisture (g/100g) | Ash (g/100g) | Protein (g/100g) | Fat (g/100g) | Crude fiber (g/100g) | Carbohy-drate (g/100g) | Total sugar (g/100g) | Energy (Kcal) | % Protein calories& |
|---|---|---|---|---|---|---|---|---|---|
| **Wheat flour** | 9.10 | 0.276 | 11.56 | 1.83 | 0.33 | 77.234 | NA* | 381.0744 | |
| **Milk powder** | 2.20 | 4.59 | 23.73 | 26.87 | NA | 42.61 | NA* | 521.885 | |
| **Mango** | 57.71 | 0.427 | 0.74 | 2.475 | 1.54 | 38.648 | NA* | 184.5083 | |
| **Soy flour** | 5.85 | 3.56 | 47.81 | 25.48 | 2.3 | 17.3 | NA* | 503.915 | |
| **Formulated baby food** | 2.78 | 1.88 | 11.91 | 8.61 | 0.58 | 74.39 | 40.42* | 433.9 | 10.98 |
| **Cerelac-1†** | 2.5 | 2.45 | 15 | 10 | 2.3 | 67.75 | NA* | 421 | 14.25 |
| **Cerelac-2#** | 2.5 | 3.2 | 12.5 | 9 | 1.0 | 71.7 | NA* | 418 | 11.96 |

**NA = Not available, †Cerelac-1 = Wheat and Milk, # Cerelac-2 = Mango, Milk & Rice,*
*&% protein calories = protein % × 4 / total energy of formulations*

***Table-2: Storage Studies of Formulated Baby Food***

| Nutrients | Month-1 | Month-2 | Month-3 | Average ± SD | % Change at Month 3 | Declared Value |
|---|---|---|---|---|---|---|
| Moisture (%) | 2.78 | 3.15 | 3.69 | 3.21±0.613 | +32.73 | - |
| Ash (%) | 1.88 | 1.79 | 1.71 | 1.79±0.630 | -9.04 | - |
| Protein (%) | 11.91 | 10.25 | 9.76 | 10.64±0.283 | -18.05 | - |
| Fat (%) | 8.61 | 8.36 | 8.29 | 8.42±0.846 | -3.72 | - |
| Carbohydrate (%) | 74.39 | 76.45 | 76.55 | 75.80±0.440 | -2.90 | - |
| Total Sugar (%) | 40.42 | 32.078 | 30.88 | 34.46±0.661 | -23.60 | - |
| Dietary Fiber (%) | 0.58 | 0.53 | 0.48 | 0.53±0.055 | -17.24 | - |
| Energy (kcal/100gm) | 433.9 | 433.22 | 430.968 | 432.696±0.031 | -0.66 | - |

***Table-3: Functional Properties of Formulated Baby Food***

| Property | Formulated baby food |
|---|---|
| Water Absorption Capacity (ml//g) | 156.35 |
| Bulk Density ($g/cm^3$) | 0.50 |
| Water Binding Capacity (g/100g) | 480.13 |
| Solubility (%) | 47.913 |
| Swelling Power ($gg^{-1}$) | 12.16 |
| Viscosity (mp/s) | 34.4 |

***Table 4: Micronutrient Analysis of Formulated Baby Food***

| Vitamin / Mineral | Formulated baby food | Cerelac 1 (Wheat & milk) | Cerelac 2 ( Mango, Milk & Rice) |
|---|---|---|---|
| **Vitamin A (µg)** | 200 | 270 | 270 |
| **Beta-carotene (µg)** | 400 | 540 | 540 |
| **Na (mg/100g)** | 224.4 | 100 | 220 |
| **K (mg/100g)** | 280 | 450 | 510 |
| **Fe (mg/100g)** | 8.0 | 7.5 | 7.5 |
| **Ca(mg/100g)** | 453.4 | 350 | 540 |
| **Mg (mg/100g)** | 5.1 | Na | Na |
| **Cr (mg/100g)** | 1.64 | Na | Na |
| **Cd (mg/100g)** | 0.1 | Na | Na |
| **Pb (mg/100g)** | bdl | Na | Na |
| **Ni (mg/100g)** | 7.96 | Na | Na |
| **Cu (mg/100g)** | 4.73 | Na | Na |
| **Zn (mg/100g)** | 10 | 3.0 | 3.0 |

*Na= Not available*

***Table 5: Microbiological Analysis of Formulated Baby Food***

| Test Parameter | 1 month | 2 month | 3 month |
|---|---|---|---|
| Standard Plate Count (cfu/gm) | <10 | 25 | 32 |
| Total Coliform (MPN/gm) | Absent | Absent | Absent |
| E.coli (MPN/gm) | Absent | Absent | Absent |
| Total Fungus (cfu/gm) | <10 | 100 | 200 |
| *Staphylococcus aureus* (cfu/gm) | Absent | Absent | Absent |

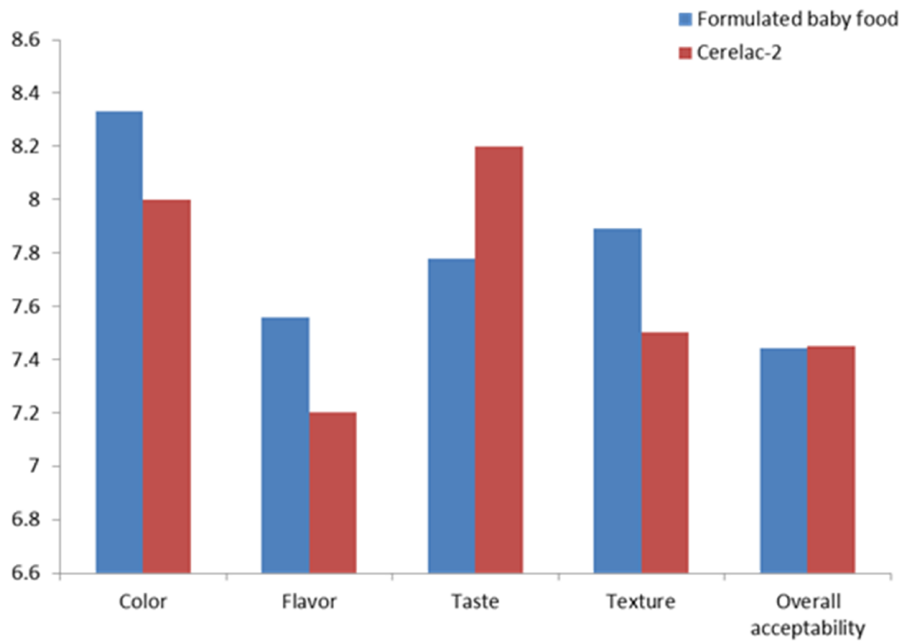


***Figure-1: Sensory Evaluation of formulated and commercial baby food.***

## 5 CONCLUSION

Infant malnutrition is an imperative health problem in Bangladesh. Proper nutrition is important to ensure growth and development of infant. Most of the supplementary baby foods are imported here in Bangladesh and these baby foods are usually beyond the affordable limit of people. Low cost local food ingredients were used to prepare a low cost baby food to meet the nutritional requirements of growing infant. The formulated baby food was found nutritionally rich and safe in microbial point of view comparable to imported baby foods. Mango flavored formulated baby food was also accepted by the test testing panel. This baby food could be an alternative of imported baby foods to meet the nutritional requirements of infants.

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## REFERENCES

[1] BDHS (2007). Bangladesh Demographic Health Survey 2007. Published: March 2009.
[2] General Economic Division, Planning Commission, GOB, (2007). MDG Midterm Bangladesh Progress Report.
[3] UNICEF/WHO (1998). Complementary Feeding of Young Children in Developing Countries: A Review of Current Scientific Knowledge. WHO/NUT/98.1. World Health Organization, Geneva. 1998. 1-228.
[4] Lalude LO & Fashakin JB (2006). Development and nutritional assessment of a weaning food from sorghum and oil-seeds. Pakistan J Nutr 5 (3): 257-260.
[5] Ijarotimi OS & Bakare SS (2006). Evaluation of proximate, mineral and antinutritional factor of home processed complementary diets from locally available food materials (Sorghum bicolour and Sphenostylis stenocarpa). J Food Techn 4(4): 339-344.
[6] FAO/WHO (1989). Codex Standards for foods for infants and children. Codex. Alimentarius Commission, Rome, Italy.
[7] Agbede JO & Aletor VA (2003). Comparative evaluation of weaning foods from Gliricidia and Leucaena leaf protein concentrates and some commercial brands in Nigeria. J Sci Food & Agric 84: 21-30.
[8] AOAC, Official Methods of Analysis: Official Method for Moisture. Method No. 925.10. Association of Official Analytical Chemists, Washington, DC (1995).

[9] AOAC, Official Methods of Analysis: Official Method for Ash. Method No. 936.03. Association of Official Analytical Chemists, Washington, DC (2000).

[10] AOAC, Official Methods of Analysis: Official Method for Fat Extraction. Method No. 920.85. Association of Official Analytical Chemists, Washington, DC (2005).

[11] AOAC, Official Methods of Analysis: Official Method for Protein. Method No. 920.87. Association of Official Analytical Chemists, Washington, DC (2005).

[12] AOAC, Official Methods of Analysis: Official Method for Crude Fibre. Method No. 920.85. Association of Official Analytical Chemists, Washington, DC (1995).

[13] Dubois, M.; Gilles, K.A.; Hamilton, J.K.; Rebers. P.A. and Smith, F. (1956). Anal. Chem., 26, p. 350.

[14] Krishnaveni, S.; Theymoli Balasubramanian and Sadasivam, S. (1984). Food Chem., 15, p. 229.

[15] Official Methods of Analysis, 16th Ed., 4th Revision, 1998, AOAC INTERNATIONAL, Gaithersburg, MD, methods 896.01, 984.15, 930.28 and 972.16

[16] Molnar, F. and Ágh, F. (1970), Rapid method for the determination of moisture and fat in dried whole milk. Journal of Tejipari Kutatasi Kozlemenyek 1970 Vol. 19 No. 4 pp. 97-99.

[17] AACC. 2000. Approved Methods of the American Association of Cereal Chemists, 10th ed. Method 61-02. The Association: St. Paul, Minnesota.

[18] Edeoga, H.O., Okwu D. E. and Mbaebie, B. O. (2003) Minerals and nutritive value of some Nigerian medicinal plants. Journal of Medicinal and Aromatic Plant Science. 25: 1010-1015.

[19] Beuchat, LR (1977). Functional and electrophoretic characteristics of succinylated peanut flour protein. j. Agric. Food Chem. 25:258-261.

[20] Sathe SK, Salunkhe DK (1981). Functional properties of great northern bean (Phaseolus vulgaris) proteins: Emulsion, foaming, viscosity and gelation properties. J. Food Sci. 46: 71-75.

[21] Oladele, A. K. and Aina, J. O. (2007). Chemical composition and functional properties of flour from two varieties of tigernut (Cyperus esculentus). African Journal of Biotechnology. 6(21): 2473-2476.

[22] Horwitz W. and GW Latimer (Eds.). (2001) AOAC Official Method 2001.13.Vitamin A (Retinol) in Foods.Vitamins and Other Nutrients.Chapter 45, p.53-56.Official Methods of Analysis of AOAC International. 18thed, Revision 2, 2007. Maryland.

[23] Gian Carlo Cruz, Zaheer Din, Christian Dale Feri, Angela Mae Balaoing, Eva Marie Gonzales, Hannah Mia Navidad, Ma. Margot Flor Schlaaff, Jennifer Winter (2009) Analysis of Toxic Heavy Metals (Arsenic, Lead, and Mercury) in Selected Infant Formula Milk Commercially Available in the Philippines by AAS, E-International Scientific Research Journal ISSN: 2094-1749 Vol: 1 Issue: 1, 2009.

[24] Larmond E. (1977) Laboratory methods for sensory evaluation of food. Canadian Government Publishing Centre, Ottawa, Canada.

[25] Badau, M.H., Adeniran, A. M. and Nkama. (2001). I. Fungi associated with various fresh meat sold in Maiduguri market, Nigeria. Sci Forum: J Pure Appl Sci; 4: 255–62.

[26] Badau, M. H., Adeniran, A.M., Nkama, I. and Baba, S.S. (1999). Bacteriological quality of fresh meat sold in Maiduguri Market, Nigeria. J Arid Agric. 9: 133-41

[27] Mosupye FM and Von Holy A. (1999). Microbiological Quality and Safety of Ready-to-eat Street-Vended Foods; Johannesburg, South Africa. Journal for Food Production. 1278-1284.

[28] Mudgil S., Aggarwal D and Ganguli A. (2004). Microbiological analysis of street vended fresh squeezed carrot and kinnow- mandarin juices in Patiala City, India. Internet Journal of Food Safety.

[29] Harrigen, N. F. and MacCance, M. E. (1976). Laboratory methods in food and diary microbiology (New York and London: Academic Press) pp. 132, 142, 258.

[30] Speck, M. L. (1976). Compendium of methods for the microbiological examination of foods (New York: American Public Health Association Inc.).

[31] World Bank, (2005). A new agenda for Women's Health & Nutrition .pp 1-96.

[32] IOM (Institute of Medicine) (2005). Dietary reference intake: Water, potassium, sodium, chloride and sulfate. National Academy press, Washington, DC.

[33] Oduro, I., W. Ellis, A. Sulemana and P. Oti-Boateng. (2007). Breakfast Meal from Breadfruit and Soybean Composite, Discovery and Innovation, 19: 238-242.

[34] Whitney EN, Hamilton EMN, Rolfes SR (1990). Understanding Nutrition, 5th edn. New York: West Publishing Company.

[35] Elkahalifa, A.O., Schiffler, and Bernhardt, R. (2005). Functional properties of sorghum flour. Food Chemistry. 92(1) 1-5.

[36] Hsu, C-L., ChenW., Weng, Y-M and Tseng, C-Y. (2003).´ Chemical composition, physical properties, and antioxidant activities of yam flours as affected by different drying methods. Food Chemistry 83 (1): 85-92.

[37] Adejuyitan, J. A., Otunola, E. T., Akande, E. A., Bolarinwa, I. F. and Oladokun, F. M. (2009). Some physicochemical properties of flour obtained from fermentation of tigernut (Cyperus esculentus) sourced from a market in Ogbomoso, Nigeria. African Journal of Food Science. Vol 3(2): 51-055.

[38] Shittu, T.A., Sanni, L.O., Awonorin, S. O., Maziya-Dixon, B. and Dixon, A. (2005). Use of multivariate techniques in studying flour making characteristics of some Cassava Mosaic Disease resistant cassava clones. African Crop Science Conference Proceedings, Vol. 7. pp. 621-630

[39] Nelson-Quartey, F. C., Amagloh, F. K., Oduro, I. and Ellis, W. O. (2007). Formulation of an infant food based on breadfruit (Artocarpus altilis) and breadnut (Artocarpus camansi). Acta Horticulturae. (ISHS) 757:212-224.

[40] WHO (2003) European region with emphasis on the former Soviet Union. WHO Regional Publications, European Series, No 87, Pp1-296.

[41] Ariahu, C.C. U.U. Ukpabi and K.O. Mbajunwa (1999). Production of African breadfruit (Treculia africana) and soybean (Glycine max) seed based food formulations 2: Effects of germination and fermentation on Microbiological and physical Properties. Plant Foods for Human Nutrition, 54: 207-216.

[42] FAO/WHO (1994). Codex Alimentarius Standards for Foods for Special Dietary Uses (including foods for infants and children), Vol. 4. Joint FAO/WHO Food Standards Program Rome: WHO, Codex Alimentarius Commission.

[43] Temple VJ, Badamosi EJ, Ladeji O and M Solomon (1996). Proximate Chemical Composition of three Locally Formulated Complementary Foods. West Afr. J. Biol. Sci. 1996; 5: 134 – 143.