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Weaning food from indigenous sources in Bangladesh

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Abstract

The aim of this study was to develop and evaluate nutritional quality of weaning food from indigenous sources. Three types of weaning food named as F-1 (wheat flour, soya flour, rice flour), F-2 (wheat flour, soya flour, malt extract) and F-3 (malted wheat flour, soya flour, peanuts, lentils, and carrots powder) were prepared for the study. Nutritional quality, functional and sensory characteristics of the developed food were investigated. Functional property as water absorption capacity, bulk density, water binding capacity, solubility, swelling power and viscosity varied from 136.24-145.83 (g/100g), 0.57-0.75 (g/cm3), 410.54-471.07 (g/100g), 35.05-48.81%, 6.16-11.79%, 33.48-39.41 (mp/s), respectively. Essential amino acids content of F-3 such as threonine, alanine, valine, methionine, isoleucine, leucine, histidine and lysine were 0.77, 0.67, 0.45, 0.47, 0.51, 0.62, 0.41 and 1.73 (g/100g), respectively. Compositional analysis of fatty acid indicates that it contains 16.01% palmitic acid, 4.27% stearic acid, 45.90% linoleic acid and 25.55% oleic acid in F-3.

Keywords: Weaning food; Nutritional quality; Functional property; Amino acid profile; Fatty acid profile

Introduction

The growth of the infant in the first or second years is very rapid and breast feeding alone will not meet the child nutritional requirement. After about four months of age the child needs supplementary feeding to provide energy and essential nutrients required for continued growth and development (WHO and UNICEF, 1998). The nutrients in recommended complementary foods complement those in breast milk. The recommended feeding practices during this time ensure that baby receives all the necessary nutrients, including those that are sometime missing for many babies (iron, zinc and vitamin A), besides the guidelines also state that an ideal weaning food must be nutrient dense, easily digestible, suitable to consistency and affordable to the target market (FAO, 1985).

Low-cost, high protein food supplement development for weaning infants is a constant challenge (Schmidt, 1983). This

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is particularly important in developing countries where malnutrition problems are still common particularly during weaning (FAO, 2010). In Bangladesh, cereals like wheat, rice, milt etc. and legumes like soya, lentils and peanuts, carrots are commonly available therefore, a strategy can be followed to formulate a highly nutritive instant weaning food which is high in protein and calories to provide a balanced diet at the weaning period as well as affordable by the parents.

Every community has a main staple food and it varies from country to country like as rice, wheat maize, cassava yam, potato etc. The staple is an excellent base for preparing babies' first weaning foods because it is usually cheaper and easily available, provides most of the nutrients needed for growth. Therefore, development of instant weaning foods based on locally available raw ingredients has been suggested by the Integrated Child Development Scheme (ICDS) and Food and Agriculture Organization (FAO, 1996) to combat malnutrition among mothers and children of low socio-economic groups. Evidence indicates that it is quite possible to improve the nutrient quality and acceptability of these cereals and legumes and exploit their potentials as human foods by adopting newer scientific processing methods (Nataranjan *et al.,* 1979). Another thing is that, the nutritional content and the digestibility of food can be increased through germination (Ozuba *et al.,* 2002).

Numerous works on weaning food were done by the previous researchers. These studies cover development of weaning food with quality and storage stability analysis. Quality evaluation of weaning food prepared from fermented cereal legume was studied by Wakil and Kazeem (2012). Wadud *et al.* (2004) developed baby food from vegetable protein. Product quality and storage stability were also analyzed for the developed product. Extruded weaning food was developed by Njoki and Faller (2001). Plahar *et al.* (2003) developed weaning food of high energy from maize, peanuts, and soybean by extrusion cooking process. Quality evaluation in terms of protein content from cooked cereal and legume based weaning food was studied by Mensa-Wilmot *et al.* (2001).

It is noticed from the recent investigation that information on instant weaning food are very limited. Therefore, the objectives of this present research were to develop a highly nutritive weaning food from indigenous food sources. The aims of this study were also to evaluate the quality of the developed food product.

Materials and methods

Collection of raw materials

Raw wheat, red lentils, peanuts, carrots and soybeans were collected from local market of Dhaka, Bangladesh to develop the weaning food. Collected sample was then stored in a refrigerator at 5^{o}C to retain the quality of the material.

Processing of raw materials

Collected wheat sample were washed thoroughly, soaked for 8 h and spread in a covering tray and then left overnight for sprouting. The sample was dried at 50^{o}C for 12 h and grinded. Finally, the malted flour was stored in a cool and dry place to avoid the moisture gain.

Raw peanuts samples was dried, grinded and packed in air tight container. Prepared peanut mash was then stored in a cool place. Healthy, mature soybean seeds were weighted and soaked overnight in 0.5% NaOH solution. The dehulled seeds were then boiled for 30 min to remove the anti-nutrient factors. The boiled seeds were strained and dried in hot air oven at 80 ^{o}C. Finally, the dried seeds were ground into powder and sieved using 100 mesh sieve.

Formulation of weaning foods

Three types of weaning food (F-1, F-2 and F-3) were prepared by mixing the prepared raw sample. The major raw materials used to formulate weaning foods were wheat flour, soya flour, rice flour for F-1; wheat flour, soya flour, malt extract for F-2 and malted wheat flour, soya flour, peanuts, lentils, carrots powder for F-3.

*Evaluation of proximate compositio***n**

Moisture, protein, ash, fat, fiber, total sugar and carbohydrate content of malted wheat flour, soya flour, and the formulated diets were determined according to AOAC (2005). Gross energy values of the raw materials and prepared foods were calculated by multiplying the values of protein, fat and carbohydrate by their respective physiological fuel values of 4.1, 9.3 and 4.1 (Edeoga *et al*., 2003).

Assessment of functional properties

Water binding capacity, water absorption capacity, bulk density, solubility and swelling power were evaluated to determine the functional properties of the developed weaning food. Water binding capacity (WBC) was examined by taking 2 g of sample and 4 ml of distilled water in a centrifuge tube. Then the mixture of sample and distilled water was shaken for one hour and centrifuged for 15 min at 2200 rpm. The calculation for determining WBC was followed as described by Beuchat (1977). Water absorption capacity was determined by the method described by Sathe and Salunkhe (1981). Bulk density, solubility and swelling power were analyzed by the methods as described by Oladele and Aina (2007). Viscosity of developed and commercial baby food samples were measured by following AACC (2000).

Evaluation of micronutrient and heavy metals

Vitamin A

Vitamin A was determined by high performance liquid chromatography (HPLC) with UV-detection after saponification and extraction (Horwitz and Latimer *et al*., 2001). Retinol was quantified in an HPLC system, using UV detection at 326 nm wave length. Vitamin A was then calculated by comparison of retinol peak heights in test samples.

*Minerals and heavy metal***s**

Minerals and heavy metals content of the formulated weaning foods were analyzed using 589 nm and 769 nm wavelength in Flame Emission Atomic Absorption Spectrophotometer (Jencons, PEP7). 10 g of dry sample was taken in a porcelain dish and then placed into a muffle furnace and heated at 1000^oC for 1 h. After burning, ashes were taken to 250 ml beaker and 50 ml of deionized distilled water and 15 ml concentrated nitric acid was added. The samples were then returned to a hot plate with continued heating and additional acid was also added until completion of digestion. 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. The atomic absorption instrument was set up and flame condition and absorbance were optimized for analyze. Then blanks, standards, and samples were aspirated into a flame in AAS.

Amino acid determination

Amino acid content of the developed weaning food samples were determined by amino acid analyzer (Sykam-S7130, Tokyo, Japan) based on HPLC system by following the amino acid analysis system instruction manual (Anonymous, 1993).

Fatty acid determination

Relative concentration of fatty acid (FA) from collected oil samples of developed baby food was measured as their corresponding methyl esters according to the method described in IUPAC (2010). About 5 to 7 drops of oil was taken in 15 ml test tube and 3 ml of 0.5 M sodium methoxide (prepared by mixing metallic sodium in methanol) was added and digested by stirring in a hot water bath for 15 min. Thereafter, the samples were cooled at room temperature and 1 ml of petroleum ether was added followed by 10 ml deionized water, mixed and allowed to settle. The distinct upper layer of methyl ester in petroleum ether was separated carefully in a capped vial and used for analysis. 200 mg of different fatty acid standard (FAME mix; Sigma-Aldrich, St. Louis, Missouri, USA) in their respective methyl ester form were dissolved separately in 10 ml petroleum ether in a series of screw capped test tubes. Aliquots of 1.0 µl FAME (fatty acid methly ester) were injected and the peaks of fatty acids were recorded for their respective retention time and presented as relative percentage as were by the automated GC software.

Rat bioassay

Nutritional quality of the prepared weaning foods were assessed according to a standard rat bioassay procedure by following OECD (2006) in the animal house section, Institute of Food Science and Technology (IFST) of Bangladesh Council of Scientific and Industrial Research (BCSIR), Dhaka, Bangladesh. Four groups of young long-evans rats (between 28-30 days) were used in this study. Each group contained four rats (2 male and 2 female). Room temperature was maintained at 18-26 ^oC with 12 h light/dark cycle. The rats were subjected to a 7 day acclimatization period.

Sensory evaluation

The supplementary foods were subjected to sensory evaluation for color, flavor, taste, texture and overall acceptability by a sensory panel consisting of 19 members of which nine members are male (age ranged from 25 to 35) and remaining 10 members are female (age ranged from 26 to 40) of BCSIR, Dhaka, Bangladesh. The presented three samples were evaluated by panelists according to 9-point Hedonic Scale (Larmond, 1977).

Statistical analysis

Results were statistically analyzed using IBM SPSS version 22. The mean and standard deviation data from the triplicate analysis of developed food samples were calculated.

Results and discussion

Proximate composition of raw materials and formulated weaning foods

The nutrient content of raw materials and formulated weaning food are shown in Table I. According to Table 1 the highest amount of protein, fat and carbohydrate was found in soya flour, peanut flour and wheat flour, respectively. It is also noticed from Table I that the highest energy value was found from peanut flour.

The mean carbohydrate content of formulated weaning food (F-3) was lower (59.56 g/100g) while F-1 and F-2 was 73.98 and 71.24 g/100g respectively. According to Codex Alimentarios Standards (FAO/WHO, 1994), the prepared weaning food should provide carbohydrate with the limit of 41.13 to 73.79 g/100g. American Dietetic Association (2008) recommends that for children 2-11 years of age, carbohydrates should make up 45–65% of total energy intake each day whether in F-3 carbohydrate content provided 51.13% of total energy. Therefore, it is noted that the formulated weaning F-3 is capable to meet the carbohydrate requirement of infants.

The protein content of F-3 was 15.88 (g/100g) which is higher than F-1 (11.81 g/100g), and F-2, (9.95 g/100g), respectively. According to Codex Alimentarious Standards, the protein content of weaning food is ranged from 14.52 to 37.70 (g/100g) (FAO/WHO, 1994). So the protein content was expected level in F-3 and the higher protein content in F-3 is due to use of soya flour, malted wheat flour and peanuts as raw materials. American Dietetic Association (2008) indicated that, in a weaning food 13% of the total energy should derived from protein whereas in F-3 protein provided 14.06% of the total energy. This implies that protein content of F-3 will be able to meet children growth demands.

F-3 contains highest fat percentage (16.49 g/100g in dry weight basis) than F-1 (7.06 g/100g) and, F-2 (10.62 g/100g). According to FAO (1985) the 40-60 percent of total energy of infant below one year of age should come from fat. Due to using peanuts the fat content was slightly higher in F-3 than the recommended level due to use of peanut. However, it provides higher calorie in the diet which is expected. According to codex standard FAO/WHO (1994) the fat content of developed weaning food should be ranged from 14.52-41.13%.

The energy content of F-3 was higher (462.80 kcal/100gm) than F-1 (418.29 kcal/100g), and F-2 (432.11 kcal/100g) and also very close to Codex Alimentarious Standards FAO/WHO (1994) (483.9 kcal/100g). According to IOM (2004) the RDA of energy for infant is 880 (kcal/day).

It is noticed from Table 1 that lower ash content varied from 2.02 to 2.58 in the formulated weaning food. The results of this study are in congruent with the reported recommendation of Protein Advisory Group (1972) which noted that the ash content should not exceed 5%.

Table I. Proximate composition of raw materials and baby foods with daily requirement (0-6 months)

Method	Moisture (%)	Ash (g/100g)	Protein (g/100)	Fat (g/100g)	Crude fiber (g/100 g)	Carbohydrate (g/100 g)	Energy (kcal)	Sugar
Wheat flour	6.81±.07	1.02±.00	13.00±.00	2.58±0.19	2.07±0.08	74.48±.07	382.70±.74	.
Soya flour	5.82±.01	3.32±.14	47.80±.01	25.55±.00	2.30±0.04	15.26±.14	494.87±1.45	.
Peanut flour	5.79±.026	3.80±.03	38.61±.03	47.00±.03	3.7±0.03	1.80±.01	602.81±.03	.
F-1	4.14±.190	2.02±.05	11.81±.28	7.06±0.52	0.42±0.02	73.98±.95	418.29±1.46	24.19±.31
F-2	4.57±.18	2.58±.03	9.95±.24	10.62±0.06	0.91±0.19	71.24±.18	432.11±.63	24.36±.33
F-3	3.81±.04	2.19±.01	15.88±1.0	16.49±0.16	2.03±.002	59.56±1.16	462.80±.28	29.57±.53
RDA	N/A	N/A	10.2/9.4,g/d(m/f)	40-60,%E	N/A	60g/d	81/82kcal/kg/d,(m/f)	N/A

Source of RDA: FAO/WHO/UNU (2004) Human energy requirements, WHO/FAO/UNU (2007) Protein and amino acid requirements in human nutrition, FAO (2010) Fats and fatty acids in human nutrition

The crude fiber percentage ranged from 0.42 to 2.03% for the developed weaning food as shown in Table 1. The results of this study match with the reported values of FAO (1985). It was reported that the crude fiber content of supplementary food should not exceed 5%.

Functional properties

The results on the functional properties of the diets are presented in Table II. The water absorption capacity of the formulated weaning food F-3 was lower (136.24 (g/100g)) than the F-1, and F-2 sample. The lower water binding and absorption capacity of weaning food indicate the thinner gruel formation with high caloric density per unit volume. Similar findings were also noted by Elkahalifa *et al*. (2005).

Bulk density of the developed weaning foods varied from 0.57 to 0.75 g/cm^3. Results of the present research (except F-1) are in concord with the reported values of Asma *et al.* (2006). It was reported from their experiment that bulk density of the baby food varied from 0.54-0.65 g/cm^3. According to Quartey *et al*. (2007), low bulk density powder are desirable in infant food preparation.

The solubility of formulated weaning food F-3 was 48.81% and swelling power was 11.79 (g/g), while the other two diets such as F-1, and F-2 contains solubility were 35.05, 38.67% and swelling power were 6.16, 8.52 (g/g). The higher solubility percentage indicates the higher functionalities of the protein in a food (Omueti, 2009).

The viscosity of the formulated weaning food F-3 (33.40 mps^{-1}) was lower than the F-1 (34.41 mps^{-1}) and F-2 (35.84 mps^{-1}) sample. Lower viscosity of weaning food indicates the increase in nutrient density (Nkama, 2001).

Table II. Functional properties and micronutrient contents (mg/100g) of the formulated food

Properties	F-1	F-2	F-3	
Water absorption capacity (g/100g)	140.92±0.53	145.83±0.29	136.24±1.82	
Bulk density (g/cm^{-3})	0.75±0.02	0.64±0.02	0.57±0.02	
Water binding capacity (g/100g)	471.07±0.51	410.54±0.04	431.14±1.01	
Solubility (%)	35.05±0.00	38.67±0.02	48.81±2.62	
Swelling power (%)	06.16±0.09	08.52±0.07	11.79±0.24	
Viscosity (mps^{-1})	34.41±1.03	39.41±0.03	33.48±1.31	
Vitamin / Mineral				RDA, 0-6 months
Vitamin A (µg), RE	92.42	92.78	141.75	375mcg/d
Na	296.55	303.44	233.30	N/A
K	139.43	180.28	250.78	N/A
Fe	7.11	12.09	7.69	0.27mg/d
Ca	230	248.8	260.33	300mg/d
Mg	81.71	164.46	144.88	26mg/d
Zn	2.53	13.72	2.83	2.8mg/d
Heavy metals				
Cr	BDL	BDL	BDL	
Pb	BDL	0.19	BDL	
Ni	BDL	BDL	BDL	
Cu	0.28		0.71	0.39

BDL= Below Detect Level, Source of RDA: FAO/WHO (2002) Human vitamins and mineral requirements

Micronutrient and trace elements

The results of micronutrient and trace elements are also shown in Table II. After analyzing three formulated baby food (F-1, F-2, F-3) Na concentration was highest in the F-3 (233.3 mg/100 g) whereas in response to mother's concerns, many baby food manufacturers have tried to keep the concentration of Na within the recommended level; 96.78–411.32 (mg/100 g) specified in the Codex Alimentarius standard for weaning foods (FAO/WHO, 1994).

The concentration of potassium in F-3 was 250 (mg/100g) which is greater than F-1 and F-2 sample. Excessive dietary intake of K has been reported to cause muscular weakness and vomiting in human (Whitney *et al*., 1990). Highest amount of Fe was found in F-2 sample while lowest was found in F-1 sample. The RDA of Fe for infant is 11 (mg/100g) (IOM, 2004). Thus the high iron content of formulated baby food can meet the infant's daily Fe needs. Calcium is an essential micronutrient in infants and young children for building bones and teeth in their early age, functioning of muscles and nerves, blood clotting and for immune defense (Whitney *et al*., 1990). The concentration of Ca was highest (260.33 mg/100g) in F-3. According to the FAO/WHO (1994), Ca concentration in weaning foods should not be less than 435.51 (mg/100g). So in that case further fortification with premix is required for the developed food. Zinc enhances the body's immune system thus, protecting children from infections. Concentration of Zn in F-2 sample was higher than the F-1 and F-3 sample. The trace/heavy metals (Cr, Pb, Ni, Cu) analysis result of both formulated and commercial foods represent that, only 0.19 (mg/100g) lead was found in F-2 and 0.28, 0.71, and 0.39 (mg/100g) of Copper were found in F-1, F-2, and F-3, respectively. Rest of all trace metals were found in all diets were below the detect level (BDL).

Amino acids

Results of amino acids for the developed weaning food are shown in Table III. It was noticed from the analysis that the developed formulated F-3 weaning food yielded eight essential amino acids followed by fourteen amino acids. The essential amino acid found in the present study for F-3 formulation was higher than the reported values of Wakil and Kazeem (2012). It was reported from their experiment that threonine, alanine, methionine, isoleucine, leucine, lysine and valine content was 0.42, 0.94, 0.54, 0.96, 0.20, 1.34, and 0.30 (g/100g), respectively. The highest amino acid content for the present study is due to use of malted wheat flour and peanuts as raw materials. The results of this experiment also match with the FAO/WHO (1973) standard as shown in Table III.

Table III. Amino acids composition of F-3 and % of RDA of amino acids met per 100g of prepared weaning food

Amino acids	F-3 (g/100g crude protein)	RDA	% RDA met
Aspartic acid	1.03	-	-
Threonine*	0.77	2.6	29
Serine	0.58	-	-
Glutamic acid	1.58	-	-
Glysine	0.47	-	-
Alanine*	0.67	-	-
Valine*	0.45	4.2	10
Methionine*	0.47	2.2	21
Isoleucine*	0.51	4.2	12
Leucine*	0.62	4.8	13
Tyrosine	0.32	-	-
Histidine*	0.41	-	-
Arginine	0.84	2.0	42
Lysine*	1.73	4.2	41

*Essential amino acid. Source of RDA: FAO/WHO (1973)

Fatty acid

Fatty acid compositions of prepared weaning foods (F-3) are given in Fig. 1. The formulated weaning F-3 contain 16.01% palmitic acid; 4.27% stearic acid; 45.90% linoleic acid and 25.55% oleic acid because of using soya flour and peanuts that provide required amount of fat content whether weaning food formulated with cooking banana, cow pea and peanuts contain 1.01% palmitic acid; 0.22% stearic acid; 2.22% linoleic acid and 3.56% oleic acid (Francisca, 2004).

Rat growth

Comparison among the weight gains of different rat groups in 21 days fed on prepared (F-1, F-2 and F-3), and laboratory diets is shown in the Fig. 2. After first week the weight increase rate was low in the rats fed on the formula F-1 (436 g), and F-2 (485g). The group weight gain was higher (527g) in the rats fed on the formula F-3 than control group (513g) fed on the laboratory diet. From the rat bioassay, the highest

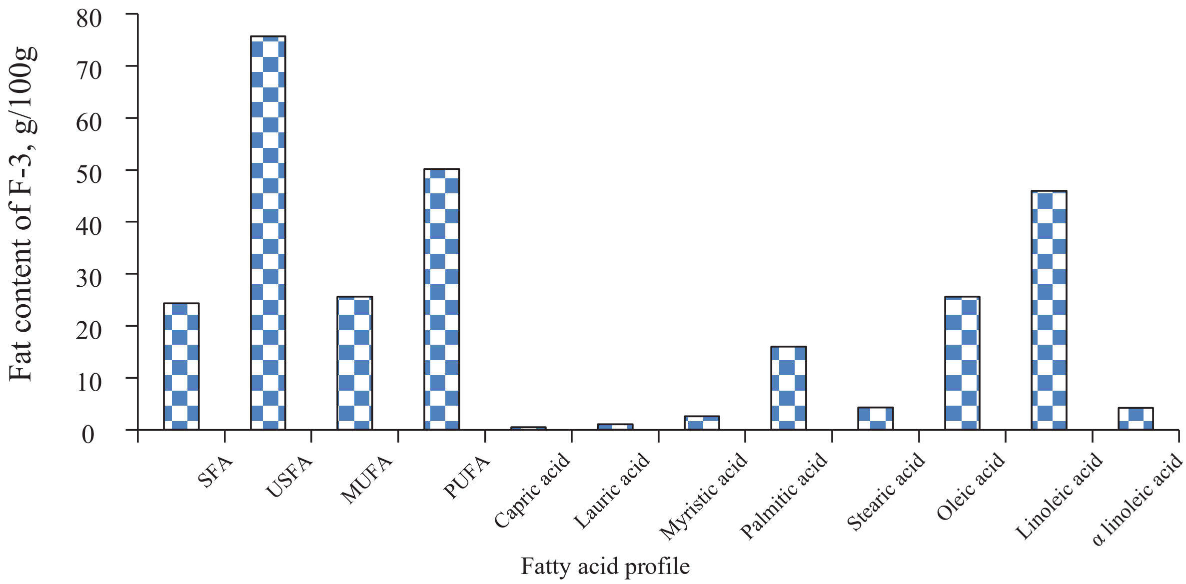

Fig. 1. Fatty acid profile of developed weaning food-3

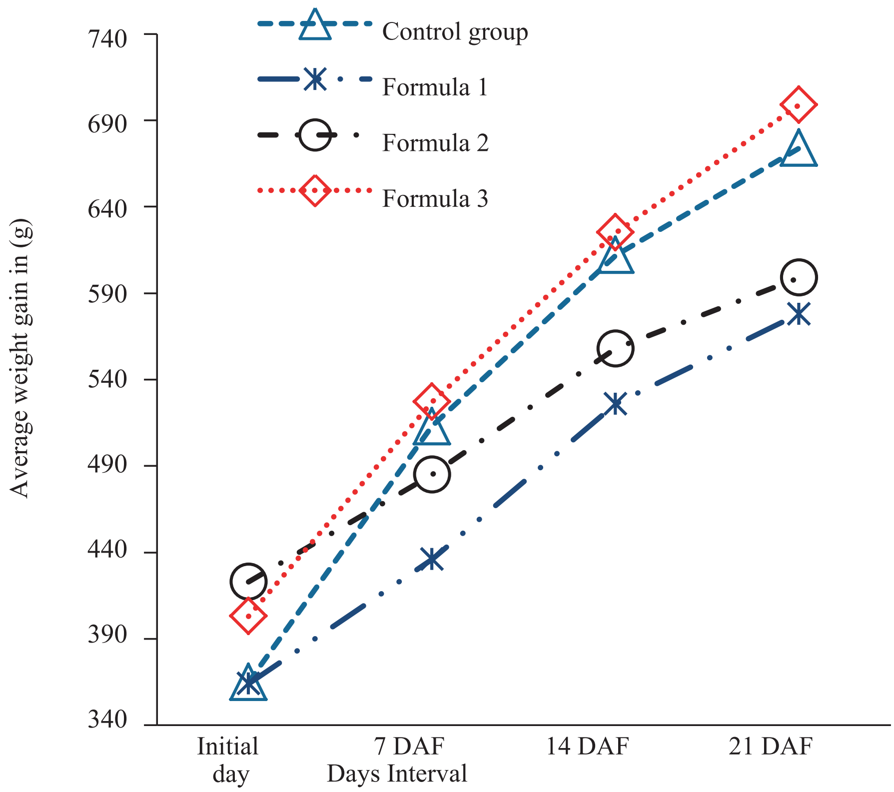

Fig. 2. Growth rate of rats after feeding different diets

growth rate was found in the rats fed on the locally prepared weaning food (F-3) than control group fed on the laboratory diet. Another causes of highest growth rate was that the highest protein percentage of the prepared weaning food (F-3) than others diets.

Sensory evaluation

Results of the sensory evaluation of developed baby food are depicted in Fig. 3. The sensorial results revealed that the color parameter of F-3 was more attractive (8.35) than F-1 (5.5) and for F-2 (7.95). The more attractive color is due to the carrot powder in F-3 sample. The nutty flavor of the formulated weaning food (F-3) (8.55) made the product more acceptable than the F-1 (6) and F-2 (6.6). The taste of commercial baby food was more acceptable than the developed baby foods due to high sugar content. So, sugar content should be increased in formulated diets to enhance taste parameters. The score of overall acceptability of the formulated weaning F-3 (7.98) was higher as compared to the F-1 and F-2 food sample.

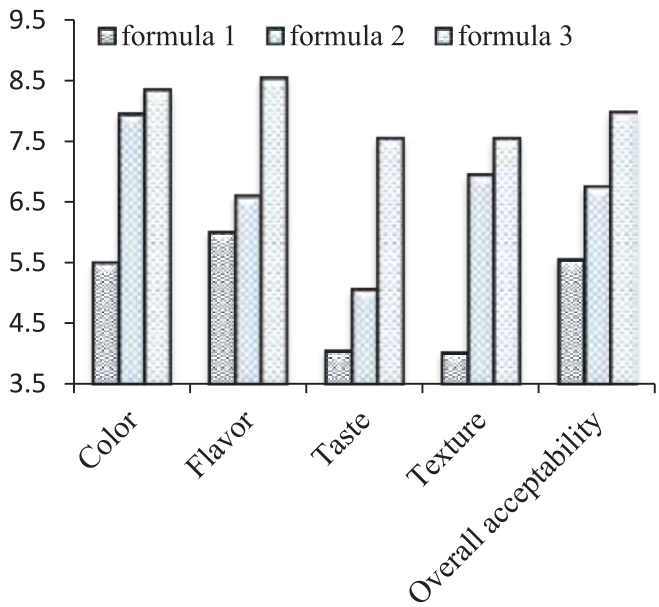

Fig. 3. Sensory evaluation of developed weaning food

Conclusion

The use of germinated wheat flour, soya flour, peanuts and lentils to develop the weaning food formulation provide high protein and calorie values with desired minerals content and improved functional and sensory characteristics. Vitamin and mineral contents are lower in F-3 than other formulated food, thus it need to be further fortified by vitamin and minerals premix. The study also showed that F-3 could be another option to fulfill the requirement of essential amino acids and fatty acids at weaning period of infants and young children. This study also implies that the formulas could be made from low cost, readily and locally available nutrient rich raw materials. Therefore, further study should be undertaken with the estimation of large scale commercial production cost of formulated diets (F-3).

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