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Physical, chemical, nutritional evaluation and sensory acceptability of barnyard millet and soybean based weaning food mixes

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Abstract

The blended formulations of weaning foods were developed to meet the energy and nutrient requirements of older infants up to six to twelve months of age. Introduction of semisolid weaning food enables infants to handle more complex carbohydrates and develops the ability to eat new foods. The physical characteristics, proximate composition, mineral content, amino acid composition and anti-nutritional factors of all the four weaning food mixes developed were analyzed using standard procedures. The physical property analysis revealed that all the four mixes were suitable for the preparation of complementary feeding mix\es due to fairly high range of dispersibility. All the products exhibited adequate amounts of carbohydrates and proteins, fats and micro nutrients. All the four mixes displayed fair levels of amino acids and very low level of anti-nutritional factors. Highest protein content was found in weaning food mix 3 (19.15%). Highest values with respect to all minerals were found in weaning food mix 4. Organoleptic evaluation demonstrated weaning food mix 2 as highly accepted by the panelists. The treatments and formulations developed in this study produced weaning food formulations rich in calories and adequate in good quality protein. These formulations can be easily prepared and nutrient content in the formulated diets were comparatively higher than commercial brands available in the market.

Keywords: protein energy malnutrition, barnyard millet, complementary food, weaning food

1. Introduction

Weaning is a process by which a baby gets used to eating family or adult food and relies less and less on breast milk (WHO, 1988) [21]. Breast milk is the natural food of babies and they should be slowly weaned from it to the regular food as the infant's need for energy and nutrients start to exceed around the age of six months. Complementary foods are essential to meet those demands. Failing to introduce complementary food or if they are given inappropriately, the growth of the infant may become unsteady. Various studies and surveys conducted by World Health Organization proves that infant and young children are at increased risk of malnutrition especially due to protein-energy malnutrition from six months of age onwards when breast milk alone is no longer sufficient to meet all nutritional requirements and complementary feedings need to be started (WHO, 2003) [22]. Over two third of the deaths among children due to malnutrition are associated with inappropriate feeding practices during the weaning period. Protein energy malnutrition resulting from the deficiencies in any or all nutrients is a global challenge that adversely affects the long term health and wellbeing of a child. Introduction of cereals after four months of age and increasing the intake slowly along with breast milk can completely meet the protein requirement. Cereals and other foods meet the energy and satiety requirement of the infants (Bureau of Indian Standards, 2006) [3].

Processed weaning foods or supplementary foods made using cereals, millets, legumes, edible oil seeds, nuts, vegetables, fruits, milk solids and sugar are manufactured in our country. Complementary foods are mainly intended to accustom the infant's digestive tract to solid foods. Due to the increased physical activity of infants, this category of food serves as a major source of calories to meet the energy requirement (BIS, 2006) [3]. According to Food Safety and standards Regulations 2011, processed cereal based complementary foods commonly known as weaning foods or supplementary food means foods based on cereal and/or legumes (pulses), soya bean, millets, nuts and edible oils seeds, processed to low moisture content and so fragmented as to permit dilution with water milk or other suitable medium. Processed cereal based complementary food shall contain milled cereals and legumes combined not less than 75%.Where the product is intended to be mixed with water before consumption, the minimum content of protein shall not be less than 15% on a dry weight basis and PER shall not be less than 70% of that of casein, (FSSAI, 2011) [6].

Most of the commercial weaning foods available are highly priced beyond the reach of a majority of the population. They are processed and packed using highly sophisticated technologies. To improve the infant and young child feeding, access to complementary feeding or weaning food is necessary and it should be timely, adequate, safe and appropriate.

2. Material and Methods

2.1 Location of the study

Barnyard millet, dried soybean, cardamom, poppy seeds, sugar, skimmed milk powder, tapioca starch, vitamin and mineral premix were purchased from the local market of Salem, Tamil Nadu. Sample cleaning, washing, sorting, drying, grinding, packing and cooking were done at the Food science and nutrition lab of Periyar University, Salem.

2.2 Weaning food mixes
Four weaning food mixes were prepared using minor barnyard millet, soybean flour, cardamom, poppy seeds, tapioca starch, sugar, skimmed milk powder, vitamin and mineral premix. Four feeding mixes (Weaning food Mix1, Weaning food Mix 2, Weaning food Mix 3 and Weaning food Mix 4, were developed with varying percentages of barnyard millet flour and defatted soy flour (20 min steamed). Flavour base was added to improve the acceptance of the complementary feeding mixes. Tapioca starch was added to improve the texture. Vitamin and mineral premix was added to improve the nutritional quality. Varying combinations of skimmed milk powder and sugar were mixed with all the four combinations. All the feeding mixes were blended thoroughly and packed in aluminum laminated pouches, sealed, marked and kept for analysis.

2.2.1 Processing and preparation
Food processing is the transformation of raw ingredients by physical or chemical means in to marketable products that can be directly served or can be easily prepared. Almost all the processing steps affect the nutrient content. The products should be consumed without delay. Most of the dried forms of weaning food mixes are stable both organoleptically and nutritionally for fairly long periods, depending upon the nature and type of ingredients used and the method of processing. Locally available ingredients like millets and pulses were first inspected for insect infestation and other dirt to select best quality. Substandard qualities were rejected to get the food material in best condition. The millets and pulses were cleaned and washed. Soaking in water was done to reduce the quantity of antinutritional factors. The materials were then dried and pulverized to minimize cooking duration. The mixes were cooked for about eight minutes, cooled to sufficient temperature and analyzed the sensory properties.

Processing of Barnyard millet flour
The selected variety of the barnyard Millet was soaked for 24 hours, steamed for 20 minutes and dried. The outer bran layers of the dried millets were removed using a polisher equipped with Emry rollers. The polished grains were pulverized using a plate mill to obtain whole flour; it was then sieved through a 44-mesh sieve (BSS).

Steaming
Soya bean was washed, steamed for 20 minutes, dried and powdered.

Roasting
Cardamom and Poppy seeds were roasted till the development of pleasant aroma and powdered.
In addition to this sugar, skimmed milk powder, vitamin and mineral premix were added to the mixes.

2.2.2 Weaning food mix formulation
The immune system of infants and young children are not fully developed. They are vulnerable to food borne illnesses and infections. We should take extra care and safety while preparing and handling their food. The ingredient formulation should be done in such a way that these products are safe and support the growth of children.
Introduction of different tastes and textures promotes biting and chewing skills. Weaning food mixes were formulated using varying combinations of minor barnyard millet, Soy flour, cardamom, poppy seeds, tapioca starch, sugar, skimmed milk powder, vitamin and mineral premix (Table 1). Child's acceptance is a major factor that determines the ingredients of a feeding mix. Flavor base was added to improve the acceptance of the complementary food. Texture can be improved by adding or removing one or two ingredients. Here tapioca starch was added as a texture enhancing agent and also it is a good source of starch. Milk solids are good sources of protein. Lactose present in the milk helps in the absorption of calcium and phosphorus and in maintaining the normal intestinal micro flora. (Swaminathan M, 1974) [19] Sucrose is commonly added as it is digested and absorbed very rapidly. Vitamin and mineral premix was added to compensate the loss of nutrients during processing. All the weaning food mixes were prepared hygienically.

Table 1: Formulations for preparing weaning food mixes

Weaning food mixes	Ingredients in percentage
Weaning food mix1	Processed barnyard millet flour 18%, defatted soy flour 12%. Other ingredients such as sugar 36% and skimmed milk powder 34%.
Weaning food mix2	Processed barnyard millet flour 14%, defatted soy flour 11 % Other ingredients such as sugar 37% and skimmed milk powder 34%.In addition a flavour base of 4% (cardamom 2% and poppy seeds 2%) was 0 added.
Weaning food mix3	Processed barnyard millet flour 16%, defatted soy flour 11 %. Other ingredients such as sugar 35% and skimmed milk powder 32%, flavour base of 4% (cardamom 2% and poppy seeds 2%). In addition tapioca starch 2% was added
Weaning food mix4	Processed barnyard millet flour 18%, defatted soy flour 11 %. Other ingredients such as sugar 32% and skimmed milk powder 31%, flavour base of 4% (cardamom 2% and poppy seeds 2%), tapioca starch 2%. In addition vitamin mix 1% and mineral mix 1% was added.

2.2.3 Packing and storing
Weaning food mixes were packed in aluminum laminated pouches, sealed, marked and stored at ambient temperature for three months. The Physical properties, chemical composition, shelf life, total bacterial count and organoleptic evaluation of the developed feeding mixes were done.

2.3 Analysis
The prepared samples of weaning mixes were subjected to physical, microbiological, nutritional and sensory analysis. Physical characteristics were analyzed in the clinical nutrition lab of Periyar University. The proximate composition, mineral

composition, amino acid profile, and anti-nutrient factors were determined in alpha omega biotech research centre.

2.3.1 Physical characteristics
Water absorption capacity, oil absorption capacity, bulk density and dispersibility were analyzed using standard procedure in triplicates.

2.3.2 Proximate Composition
Moisture, water activity, carbohydrates, crude fat, crude protein and total ash contents of the developed composite complimentary feed mixes were analyzed using AOAC protocols (AOAC, 1984) [1]. Energy value was calculated using Atwater's conversion factors.

2.3.3 Minerals analysis
For each sample potassium and sodium content was assessed by flame spectrophotometry, while calcium, magnesium, manganese, iron, zinc and copper were analyzed using an atomic absorption spectrophotometry. Phosphorus was analyzed using Technicon Auto-analyzer method.

2.3.4 Amino acid composition
Amino acid compositions of samples were measured on hydrolysates using amino acid analyzer (Sykam-S7130) based on high performance liquid chromatography technique.

2.3.5 Anti-nutritional parameters
The method of Harborne (Harborne J.B, 1973) [7] was used to determine qualitatively and quantitatively the presence of saponin, tannin, alkaloid, flavonoid, cyanogenic glycoside, Oxalate, phytate, trypsin inhibitor of the formulated mixes.

2.3.6 Organoleptic evaluation
The developed weaning food mixes in the dry form were cooked in boiling water for seven to eight minutes on slow fire and subjected to sensory evaluation. Sensory evaluation was carried out using mothers of weaning children (n=10). They were asked to evaluate the colour, flavor, taste, mouth feel and overall acceptability based on a nine point hedonic scale; like extremely=9, like very much=8, like moderately=7, like slightly=6, neither like nor dislike=5, dislike slightly=4, dislike moderately=3, dislike very much=2, dislike extremely=1

3. Results
3.1 Physical characteristics
The physical attributes such as water absorption capacity, oil absorption capacity, bulk density and dispersibility of all the four weaning food mixes were determined (Table 2). Among the four feeding mixes, weaning food mix 4 was found to have lower water absorption capacity and weaning food mix 3 got lower oil absorption capacity. Bulk density of the mixes ranged from 0.27 to 1.33 per cent and showed higher range of dispersibility for all the four mixes, which makes them suitable for preparation of feeding mix.

Table 2: Physical characteristics of weaning food mixes

Weaning Food Mixes	WAC	OAC	BD	DISPERSIBILITY
Weaning food mix 1	0.42±0.01	1.34±0.13	0.27±0.12	64±1.30
Weaning food mix 2	0.70±0.02	2.11±1.07	1.03±0.87	53±2.17
Weaning food mix 3	1.28±0.21	0.78±0.38	1.33±0.34	52±0.21
Weaning food mix 4	0.11±0.02	1.11±0.02	0.54±0.04	57±0.20

3.2 Proximate composition
The chemical compositions of the formulated weaning food mixes were presented in Table 3. Moisture content of products ranged from 1.03 to 3.62 per cent. Carbohydrate content of the products ranged from 70.59 per cent to 74.07 per cent. Protein content ranged from 18.36 to 19.15 per cent. Fat and ash contents ranged from 2.20 per cent to 3.74 per cent and 3.19 to 3.91 per cent respectively. According to the recommendations of Food safety and standards authority of India (FSSAI), 2006 processed cereal based complementary foods commonly known as weaning foods should contain moisture, not more than 4 per cent, total protein, not less than 15 per cent, total carbohydrate, not less than 55 per cent, and total ash, not more than 5 per cent.

Table 3: proximate composition of weaning food mixes

Weaning food Mixes	Constituents (%)					
	Moisture	Carbohydrates	Protein	Fat	Ash	Energy(Kcal/100g)
Weaning food mix 1	1.03±0.01	73.65±0.33	18.90±0.31	2.20±0.09	3.19±0.04	390±11.93
Weaning food mix 2	1.44±0.04	74.07±0.36	18.36±0.20	2.51±0.05	3.66±0.08	392.31±23.68
Weaning food mix 3	3.21±0.01	70.59±0.23	19.15±0.34	3.74±0.06	3.32±0.07	392.62±33.71
Weaning food mix 4	3.62±0.02	71.02±±0.36	18.48±0.24	2.99±0.07	3.91±0.05	384.91±27.38

Nine different minerals sodium, potassium, calcium, magnesium, manganese, iron, zinc, copper, phosphorus was analyzed and results were summarized in table 4. All the mixes displayed reasonable levels of mineral constituent. Among the four mixes, calcium, sodium, potassium, iron and magnesium were highest in weaning food mix 4. Phosphorus, copper, manganese and zinc were highest in weaning food mix 1. Relatively lower levels of mineral content were found in mix 2. Iron is one of the most important mineral requirements of infants (Niccum W L *et al*, 1976) [14]. Iron supplements prevent the development of iron deficiency anemia. According to National Institute of Nutrition, Hyderabad the RDA's for calcium, magnesium and iron for infants from six months to twelve months of age are 500 mg, 45 mg and 5 mg per day respectively (NIN, 2006) [15].

Table 4: Mineral compositions of weaning food mixes

Sl.NO	Minerals (In ppm)	Weaning food mixes			
		Weaning food mix 1	Weaning food mix 2	Weaning food mix 3	Weaning food mix 4
1	Na	5.27 ± 0.31	3.56 ± 0.51	4.9± 0.01	5.59 ± 0.34
2	K	48.98 ± 0.33	11.35± 4.61	152.8 ± 1.49	415.87 ± 7.88
3	Ca	24.36 ±0.69	11.37 ± 8.21	114.79 ± 1.32	295.51 ± 2.56
4	Mg	7.49 ± 0.14	5.63 ± 0.37	7.41 ± 0.19	13.29 ± 0.20
5	Mn	15.61 ± 0.49	10.56 ± 0.27	11.46± 0.32	13.33 ± 0.24
6	Fe	17.44 ± 0.23	11.25 ± 0.72	18.84 ± 0.58	19.16 ± 0.11
7	Zn	6.01 ± 0.08	4.51 ± 0.47	5.35 ± 0.23	5.96 ± 0.02
8	Cu	13.97 ± 0.56	10.21 ± 0.10	11.69 ± 0.06	12.41 ± 0.14
9	P	31.46 ± 0.67	15.49 ± 0.36	16.68 ± 0.26	24.75 ± 2.48

3.3 Amino acid profile

The amino acid profile of the developed products were summarised in table 5. All the four weaning food mixes contained adequate levels of non-essential amino acids and essential amino acids (Table 5). Weaning food mix 1 was high in leucine, lysine, Phenylalanine, Valine, glutamic acid and methionine compared to other three mixes. Highest values for histidine, arginine and proline were determined in weaning food mix 2. Tyrosine, alanine, threonine, cysteine and serine were highest in weaning food mix 4. Weaning food mix 3 contained highest level of glycine and isoleucine. Addition of ingredients should be in such a way that the protein value or amino acid score created by this combination is similar to that recommended for infants. According to the Food and Agriculture Organization and the World Health Organization, the RDA for reference protein during infancy is 14 g/day, and the net dietary protein (NDP) calories percent values are 8.0% and 7.8% for infants and toddlers, respectively (FAO/ WHO, 1985) [5, 16]. The Protein Advisory Group recommends a minimum protein efficiency ratio (PER) of 2.1 (Wondimu A *et al*, 1996) [23] and a net protein utilization (NPU) of not less than 0.6 (Al-Othman AM *et al.* 1997) [2].

Table 5: Amino acid profile of developed weaning food mixes

Sl:No	Amino Acids (g/100g)	Weaning food mixes			
		Weaning food mix 1	Weaning food mix 2	Weaning food mix 3	Weaning food mix 4
1	Isoleucine	1.91 ± 0.07	1.74 ± 0.01	5.41 ± 0.01	2.04 ± 0.04
2	Leucine	5.00 ± 0.02	2.52 ± 0.02	2.81 ± 0.01	3.51 ± 0.10
3	Lysine	29.14 ± 0.02	11.38 ± 0.07	4.87 ± 0.05	6.90 ± 0.07
4	Cysteine	0.87 ± 0.02	0.04 ± 0.03	1.54 ± 0.01	1.95 ± 0.06
5	Methionine	29.52 ± 0.26	27.80 ± 0.16	27.39 ± 0.39	29.28 ± 0.07
6	Tyrosine	5.53 ± 0.37	4.96 ± 0.01	4.35 ± 0.02	7.78 ± 0.07
7	Phenylalanine	7.25 ± 0.05	2.90 ± 0.08	5.41 ± 0.01	4.96 ± 0.01
8	Threonine	2.35 ± 0.02	0.06 ± 0.04	1.97 ± 0.02	3.96 ± 0.02
9	Valine	4.38 ± 0.26	1.60 ± 0.07	3.89 ± 0.05	4.36 ± 0.05
10	Histidine	3.17 ± 0.02	3.50 ± 0.28	1.51 ± 0.01	2.97 ± 0.01
11	Arginine	4.54 ± 0.23	6.73 ± 0.04	2.45 ± 0.08	2.19 ± 0.01
12	Glutamic acid	12.26 ± 0.03	3.45 ± 0.15	3.56 ± 0.13	4.22 ± 0.02
13	Serine	4.58 ± 0.23	12.60 ± 0.02	11.67 ± 0.02	14.84 ± 0.04
14	Proline	11.10 ± 0.03	27.93 ± 0.04	6.24 ± 1.16	6.94 ± 0.04
15	Glycine	0.22 ± 0.06	0.54 ± 0.04	3.33 ± 0.03	0.86 ± 0.05
16	Alanine	2.21 ± 0.07	1.65 ± 0.02	1.28 ± 0.02	2.93 ± 0.02

3.4 Anti-nutritional factor analysis

Anti-nutritional compounds exist as a natural component of cereals, legumes and other plant foods. Due to the relatively high nutrient requirements of children from 6 to 24 months of life, anti-nutrients in complementary foods can negatively affect the nutritional status of these children (Nanna, Roos *et al,* 2013) [12]. Quantities of anti-nutritional factors in the products are summarized in table 6. Among the products, antinutritional factors like oxalates, tannins, phytates, cyanogenic glycosides and trypsin inhibitors were found lowest in weaning food mix 2. Alkaloids and flavonoids were lowest in weaning food mix 1.Comparatively higher values for Alkaloids, phytates, saponin and trypsin inhibitors were found in weaning food mix 4.

Table 6: Anti-nutritional factors Analysis of weaning food mixes

S.NO	Anti-nutritional factors(mg /100 g)	Weaning food mixes			
		Weaning food mix 1	Weaning food mix 2	Weaning food mix 3	Weaning food mix 4
1	Oxalates	0.25±0.02	0.08±0.01	0.8± 0.02	0.80 ± 0.06
2	Tannins	5.13 ± 0.04	4.16 ± 0.01	6.9± 0.04	6.47 ± 0.02
3	Phytates	0.73 ± 0.00	0.48 ± 0.03	0.5± 0.03	0.77 ± 0.04
4	Saponin	48.4± 1.91	50.4± 0.01	43.0± 2.08	68.2± 0.04
5	Alkaloids	107.6 ± 1.73	125.3 ± 0.91	185.9± 2.86	246.5 ± 4.98
6	Flavonoids	130.3 ± 0.57	152.1 ± 2.04	168.7 ± 0.02	230.4 ± 0.59
7	Cyanogenic glycoside	29.45 ± 0.12	25.27 ± 0.01	28.17 ± 0.01	28.25 ± 0.03
8	Trypsin inhibitor	1.66 ± 0.19	1.25 ± 0.03	3.71 ± 0.44	6.24 ± 0.04

3.5 Sensory evaluation

The results of sensory evaluation of the weaning food mixes are given in Table 7. Weaning food mix 2 got the most acceptable colour with a mean value of 7.5, whereas weaning food mix 1 had the least acceptable colour with a mean value of 6.8. The inclusion of flavour base increased the acceptability of flavour which was evident in the sensory score. The flavour scores of weaning food mixes 2, 3, and 4 showed a higher value when compared with that of weaning food mix 1, to which flavour base was not added. Mothers gave a high acceptability score of 8.4 for weaning food mix 2 for flavour. Weaning food mix 2 got the highest value (7.5) for taste as well. The least score of 6.7 in terms of flavour was given to weaning food mix1. Mouth feel, taste and overall acceptability between the samples varied slightly.

Table 7: Sensory scores of weaning food mixes

Weaning food mixes	Colour	Flavour	Mouth feel	Taste	Overall acceptability
Weaning food mix 1	6.8±1.9	6.7±1.3	7.1±1.3	7.1±0.8	6.9±1.4
Weaning food mix 2	7.5±0.7	8.4±0.3	7.2±0.9	7.5±0.4	7.7±1.0
Weaning food mix 3	7.2±1.2	8.3±0.5	7.2±1.3	7.3±1.1	7.5±0.7
Weaning food mix 4	7.2±1.7	8.2±0.1	7.1±0.9	7.2±0.7	7.4±0.8

3.5.1 Influence of storage on Taste of the complementary feeding mixes

Taste, one of the major sensory attribute of experimental weaning food mixes were affected by the type of ingredients used. However storage exerted a slight change in this attribute. After storage for 90 days weaning food mix 4 got the highest score for taste (6.6). Lowest taste acceptance score was obtained by weaning food mix 1 (5.8). All the samples remained above the acceptance level (Table 8).

3.5.2 Influence of storage on flavour of the complementary feeding mixes

Flavour of the food is a main factor that influences the taste and overall acceptability of the food. The acceptability of infant foods is greatly affected by the odour. Food once is rejected by the child can be made acceptable by changing the aroma and flavour. Weaning food mix 3 got a highest score of 7.8 after three months storage. Lowest score for flavour was given to weaning food mix 1 with 5.8 (Table 8).

3.5.3 Influence of storage on mouth feel of the complementary feeding mixes

The mouth feels of the weaning food mixes were slightly affected by the three months storage conditions. The highest value was scored by weaning food mix 3 (6.8) followed by weaning food mix 2 (6.2). The texture score before storage was 7.2 for both the mixes (Table 8). Weaning food mix 1 got the lowest score for mouth feel (6.0) after three months storage.

3.5.4 Influence of storage on overall acceptability of the complementary feeding mixes

The overall acceptability scores of weaning food mixes ranged from 7.7 to 6.9 before storage and after storage of three months it changed to a range of 6 to 6.9 (Table 8). Weaning food mix 3 and 4 got the highest acceptability after three months storage.

Table 8: Influence of storage condition on sensory attributes of weaning food mixes

Weaning food mixes	Flavour		Mouth feel		Taste		Overall acceptability	
	Before storage	After storage	Before storage	After storage	Before storage	After storage	Before storage	After storage
Weaning food mix 1	6.7±1.3	5.8±0.03	7.1±1.3	6±0.0	7.1±0.8	5.8±0.2	6.9±1.4	6±0.8
Weaning food mix 2	8.4±0.3	7.3±0.01	7.2±0.9	6.2±1.02	7.5±0.4	6.3±0.1	7.7±1.0	6.7±0.1
Weaning food mix 3	8.3±0.5	7.8±0.01	7.2±1.3	6.8±0.9	7.3±1.1	6.3±0.0	7.5±0.7	6.9±1.1
Weaning food mix 4	8.2±0.1	7.6±0.1	7.1±0.9	6.1±0.9	7.2±0.7	6.6±1.0	7.4±0.8	6.9±0.8

4. Discussion

The most important factors that are responsible for the malnourishment among children are late introduction of supplementary foods and bad feeding practices, expensive commercial weaning foods, expensive ingredients like protein etc. More over cereal based complementary foods prepared using locally available staple foods are poor in protein quality. Thus children are not able to meet the energy and protein requirement which eventually leads to protein energy mal nutrition. Several strategies can be applied to overcome the nutrient deficiencies. Food based approaches is one among them. By using a combination of cereals and pulses along with plant and animal proteins, we can develop complementary feeding mixes that are high in protein, fat and other vital nutrients.

Weaning food mixes prepared based on minor barnyard millet, defatted Soy flour, cardamom, poppy seeds, tapioca starch, sugar, skimmed milk powder, Vitamin and Mineral premix exhibited a high rate of acceptance with respect to sensory and nutritional quality. In the current study all the evaluated weaning food mixes were comprised of animal and plant protein. Here soybean and barnyard millet are the major sources of plant protein. Millets have various nutritional qualities and are called as nutri-cereals (Hulse J H *et al*, 1980, Singh K P *et al*, 2012) [8, 18]. The results of the proximate composition analysis of the four weaning food mixes confirms that moisture, protein and fat values were within the range of values prescribed by FSSAI, 2006 [6]. Weaning food mix 3 was identified with the highest amount of protein (19.15 per cent) among the four mixes. The energy values of the formulated mixes were in the range of 384.91 Kcal/100g to 392.62 Kcal/100g, which is adequate for the exceeded energy requirements of a child. According to Codex Alimentarius International food standards, the energy density of processed cereal-based foods intended for feeding infants as a complementary food should not be less than 3.3 kJ/g (0.8 kcal / g) (Codex,1981) [4].

Fortification of weaning foods with nutrients serves to correct the nutritional deficiency of the average diet. The method of addition is dependent on the processing systems and preferences. Mineral analysis revealed highest values for weaning food mix 4. This could be due to the incorporation of vitamin and mineral premix in the mix 4. Amount of sodium and Potassium ranged from 3.19 ppm to 5.59 ppm. Calcium content was highest in weaning food mix 4 (295.51 ppm) and lowest in weaning food mix 2 (11.37 ppm). The iron content of the samples ranged from 11.25 ppm to 19.16 ppm, which satisfied the recommended nutrient intake for age group 7 to 12 months by WHO, which is 8.5 ppm (WHO, 2000) [20]. National institute of Nutrition, Hyderabad recommends a daily intake of 370 mg of sodium and 475 mg to 1275 mg of potassium by infants of age 7 to 12 months (NIN) [13]. All the samples displayed satisfactory levels of magnesium, manganese, zinc, copper and phosphorous. The result from mineral analysis shows that the micro nutrient density is adequate for the healthy growth and development of children.

Legumes and cereals are considered ideal dietary partners because the amino acids making up their proteins are very good complements (Michaels TE, 2004) [11]. Cereals are deficient in lysine, legumes have been reported to contain adequate amounts of lysine, but are deficient in sulfur containing amino acids methionine, cystine and cysteine. Therefore, intentional combination of cereals and legumes provide diets with balanced amino acid composition (Michaels TE, 2004) [11]. The lysine content of the four products was considerably higher due to the incorporation of pulses. The level of alanine was highest in weaning food mix 4 (2.93 g/100g). Reasonable amounts of Proline (27.93g/100g) and Glutamic acid (3.45 g/100g) was found in weaning food mix 2. A combination of plant protein (Soya bean) and animal protein (Skimmed milk powder) fulfills the requirements of protein, especially essential amino acids.

Anti-nutritional factor analysis is of great importance in complementary feeding mixes as these could impart negative changes in the growth of children. Many studies confirmed that gain in body weight and food utilization efficiency is lower when the food contains considerable amounts of antinutritional agents. High levels of dietary antinutritional factors has been reported to cause significant reductions (up to 50%) in protein digestibility and/or amino acid bioavailability values in animal models and/or humans (Gilani *et al*, 2005) [17]. Although legumes like soybean play an important role in the increasing the overall protein, fat and nutritional value of foods, it contains many antinutritional factors like trypsin inhibitors, saponin, lectin etc. (Liener, I.E, 1994) [9]. Phytates, oxalates and tannins are found in most of the plants. The analysis for anti-nutrient factor in the samples revealed that the products contain a relatively low level of anti-nutritional factors. Oxalate content ranged from 0.08 to 0. 80 mg/100g. Tannin ranged from 4.16 to 6.9 mg/100g. Phytates ranged from 0.48 to 0.77 mg/100g. Saponins ranged from 43.00 to 68.20 mg/100g. Alkaloids and Flavonoids ranged from 107.36 to 246.5 mg/100g and 130.3 to 230.4 mg/100g respectively. Cyanogenic glycosides and trypsin inhibitors ranged from 25.27 to 29.45 mg/100g and 1.25 to 6.24 mg/100g respectively. Weaning food mix 4 was identified with highest levels of anti-nutrient factors among the four mixes (Table 6). Comparatively lower values were found in weaning food mix 2. The relatively low proportion of antinutritional factors could be due to the processing steps including soaking and sprouting. Most of the anti-nutritional factors are reduced or inactivated by traditional cooking and food processing. This improves flavor, palatability and increases the bioavailability of nutrients (Gebrelibanos *et al*, 2013) [10].

All the four weaning food mixes were rated ‘like moderately’ by the panelists. In terms of flavour and taste weaning food mixes 2, 3, and 4 scored higher values than weaning food mix 1. This could be due to the addition of flavour base in these mixes. There for it could be concluded that the addition of flavour base has a positive effect on the flavour and taste of the product.

The sensory quality of the four feeding mixes showed slight variation during a 90 days storage at room temperature (Table 8). The taste, flavour, mouth feel and over all acceptability were found to be slightly changing during the storage period. Packing with suitable materials and modifications in processing techniques will be necessary since the weaning food mixes exhibited slight variation in acceptability. Yet the four combinations met the acceptability criteria for complementary foods. All the formulations were organoleptically acceptable, obtaining ‘like slightly’ to ‘like very much scores.

5. Conclusion

This study showed that weaning food mixes can be produced using locally available ingredients like barnyard millet, soybean, skimmed milk powder, sugar and flavour base and simple technologies. Barnyard millet can be effectively used as an acceptable energy supplement. The treatments and formulations developed in this study produced high energy, high protein and nutrient rich complementary foods. This provides substitutes to the weaning foods available in the market. The inclusion of soya bean, milk solids and barnyard millet improved the protein availability of the products. The nutritional and sensory analysis of the weaning food demonstrated most satisfactory results. Based on the nutritional status and the acceptability of the child a particular weaning food mix can be recommended.

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7. References

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