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Nutritional Textural and Organoleptic Evaluation of Barnyard Millet based Weaning Food mixes

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Abstract

Complementary foods are the chief source of energy requirement for children during the age of six to twelve months. Four different formulations of weaning foods were developed to meet the exceeded energy and nutrient requirements of growing infants. The proximate compositions, viscosity, textural and organoleptic properties of all the four weaning food mixes were analyzed. All the four formulations displayed adequate amounts of carbohydrates, proteins, fats and micro nutrients. Highest protein content was found in weaning food mix 3 (19.15%). Viscosities of weaning food mixes were in the range 29162±108.9 cP to 398.7±17.9 cP at shear rates ranging from 0.3 to 60 rpm. Weaning food mixes exhibited decreased viscosities at higher rotational speed (60 rpm) which are desirable for weaning foods. Texture profile analysis displayed significant difference (P<0.05) in adhesiveness and stringiness of weaning food mixes with commercial infant formula. Acceptability scores for weaning food mix ranged from 6.3±0.87 to 8.52± 0.84. Evaluation of acceptability by face reaction of babies revealed weaning food mix 2 as the best formulation in terms of taste and flavour.

Keywords: *Complementary foods, weaning foods, Barnyard millet, Infant formulations*

1. Introduction

To meet the exceeded energy and nutrients demands of the growing infant complementary foods should be provided. Processed weaning foods manufactured using cereals, millets, legumes, edible oilseeds, nuts, vegetables, fruits, milk solids, and sugar are available in a wide variety of flavour and taste. Complementary foods are a chief source of energy requirement for children (BIS.2006) [6]. According to Food Safety and Standards Regulations, 2011, cereal-based complementary foods (weaning foods) are processed using cereal and legumes (pulses), soya bean, millets, nuts, and edible oils seeds, to low moisture content. Milled cereals and legumes in processed cereal-based weaning food should not be less than 75%. Protein content should not be less than 15% on a dry weight basis, and PER should not be less than 70% of that of casein, (FSSAI, 2011 regulations) [8].

An infant's diet gradually progresses from liquid foods to semisolid foods during the first year. During that period infants experience different consistencies of food. According to a study by Steiner, 1979 human infants are born with genetic predispositions that can influence the acceptability of various tastes and flavors (Steiner, 1979) [17]. Mennella and Beauchamp conducted a study stating that development of food likes and dislikes are dependent on some factors including maternal diet during pregnancy, lactation and early feeding regime (Mennella and Beauchamp, 1991) [15]. Various studies suggest that the texture of food can influence the acceptance of food in adults (Kalviainen, Schlich & Tuorila, 1998, Jaeger, Andani &Wakeling, 1998) [11, 10]. However little is known about an infant's acceptability about the texture of the food.

Determination of textural properties is an excellent method to assess the texture as it is one of the main factors that regulate the acceptability of food products. Texture profile analysis can be used to simulate the process that takes place in the mouth during chewing (Brncis, *M et al.*, 2009)[5]. Szczesniak, 1972 and Lundy et al., 1998 demonstrated that during the development of teeth or jaw movements, the texture of the food influences the child's acceptability and unacceptability. During the age of six to twelve months, infants responded negatively to difficult to chew textures than toddlers. Infants showed a strong preference for the softer and smoother texture and consumed more (Lundy et al., 1998) [13].

Several studies revealed that the diet of the infants should be complemented with a variety of different flavors and textures. This variety will enhance the acceptance of novel foods, and they will learn to like different textures and also have a long-term impact on later taste preferences. This study examined the nutritional, textural and organoleptic properties of four weaning food mixes formulated based on barnyard millet. This study also discussed the influence of barnyard millet on the viscosity and textural properties of the weaning food mixes.

2. Materials and methods

2.1 Sample preparation

Four different weaning food mixes were formulated using varying combinations of processed minor barnyard millet flour, defatted Soy flour, cardamom, poppy seeds, tapioca starch, sugar, skimmed milk powder, vitamin, and mineral premix. Weaning food mix 1 was formulated using 18% processed barnyard millet flour, 12% defatted soy flour, 36% sugar and 34% skimmed milk powder. Weaning food mix 2 was formulated with 14% processed barnyard millet flour, 11 % defatted soy flour, 37% sugar and 34% skimmed milk powder. Also, 4% flavour base (cardamom 2% and poppy seeds 2%) was added. Weaning food mix 3 was formulated using 16% processed barnyard millet flour, 11 % defatted soy flour, 35% sugar and 32% skimmed milk powder, 4% flavor base of (cardamom 2% and poppy seeds 2%). Also 2% tapioca starch was added. Weaning food mix 4 was formulated using 18% processed barnyard millet flour, 11 % defatted soy flour, 32% sugar, 31% skimmed milk powder, 4% flavour base of (cardamom 2% and poppy seeds 2%), 2% tapioca starch. Also, 1% vitamin mix and 1% mineral mix was added.

2.2 Chemical Analysis.

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 Viscosity analysis

The viscosity was measured with a Fungi lab viscolead viscometer. The weaning food mixes were cooked at 90°C for 5mins and measured on the same day as prepared. Measurements were taken at room temperature. The viscosity was measured in centipoises (cP) at eight different rotational speeds (0.3 to 60 rpm).

2.4 Textural properties

The texture profile analysis of Weaning food mixes was performed using Perten Instruments TVT 6700 texture analyzer. The instrument was fitted with a 45" stainless steel cone probe. Samples were tested after exactly 10 min had elapsed following cooking. Weaning food mix were cooked with sufficient water at 90°C for 5 minutes and subjected to texture analysis. Measurements were carried out at room temperature (~28°C). Calibration settings used were: 5 kg load cell with compression of 15mm.The measurement mode settings for single cycle penetration test initial speed-1.0mm/sec, test speed-2.0mm/sec and retract speed- 2.0 mm/sec; trigger type at auto-10 g; and data rate: 200 pps

2.5 Organoleptic evaluation

Sensory evaluation of the four weaning food mixes, after cooking with boiling water for seven to eight minutes on slow fire was carried out using 40 babies from three rural community development blocks of Salem district (n=40). The test was carried out as recommended by Kroll (1990) using a nine-point facial hedonic scale (super good=9, really good=8, good=7, just a little good=6, may be good or bad=5, just a little bad=4, bad=3, really bad=2, super bad=1). The evaluation for acceptability was based on the face reaction of babies (Figure 1)

3. Results

3.1 Chemical analysis

The chemical compositions of the formulated weaning food mixes were presented in Table 1. The moisture content of products ranged between 1.03±0.01 to 3.62±0.02 per cent. Carbohydrates ranged from 70.59±0.23 per cent to 74.07±0.36 per cent. Protein content ranged between 18.36±0.20 to 19.15± 0.34 per cent. Fat contents ranged from 2.20± 0.09 per cent to 3.74± 0.06 per cent, and ash content ranged from 3.19±0.04 to 3.91±0.05 per cent. Food safety and standards authority of India (FSSAI), 2006 endorses that processed cereal-based complementary foods should contain moisture, 4 per cent maximum, 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 (FSSAI, 2006)

3.2 Viscosity analysis

The flow behavior of the four cooked weaning food mixes was observed by measuring the viscosity at different rotational speeds and compared with a commercial weaning food formula. The values were reported as centipoise (cP). Analysis indicated that the viscosity of weaning food mixes was significantly different at various rotational speeds. All the four weaning food mixes exhibited non-Newtonian shear thinning behavior. The viscosity values of the weaning food mixes ranged from 29162±108.9cP to 398.7±17.9 cP at rotational speeds ranging from 0.3 to 60 rpm. Viscosities of the four weaning food mixes at a rotational speed of 60 rpm were lower when compared to that of the commercial weaning food formula at the same rotational speed (Table 3). Reduced viscosity is a good indicator of increased nutrient density (Nkama et al., 2001) [16]. Low viscosity is desirable for proper feeding, as well as easy to consume by babies. It is also considered as an appropriate characteristic in weaning food blends for infants. Viscosities at various shear rates were given in Table 3

3.3 Textural properties

Texture profile analysis of four weaning food mixes and commercial weaning food formula was performed using a texture analyzer. The data obtained were recorded by a computer that was linked to the analyzer. Parameters recorded from the test curves were adhesiveness, stickiness, stringiness, and resilience. The weaning food mixes were cooked with sufficient water and subjected to texture analysis. Adhesiveness of the weaning food mixes ranged from 0.05±0.02 to 1.25±0.12 J. Stickiness varied from -3.00 ±1.00 to -16.00 ± 1.73 g. Stringiness varied between 0.07±0.05 to 0.52±0.04 mm, and resilience ranged from 0.07±0.05 to 0.52±0.04. Weaning food mix 2 showed the highest textural parameters and weaning food mix 3 had the lowest values. The textural parameters like stickiness and resilience of weaning food mixes were not significantly different (P>0.05) from the commercial weaning food formula; however, there was significant difference (P<0.05) in the adhesiveness and stringiness values (Table 2)

3.4 Sensory evaluation

The results of sensory evaluation of the weaning food mixes are given in Table 7. The facial hedonic test was conducted to find out how much babies like or dislike each product. Weaning food mix 1 was evaluated as good with an average score of 6.5±0.64. Weaning food mix 2 and 3 were evaluated as really good with scores 8.52±0.84 and 8.25±0.54 respectively. Weaning food mix 4 was evaluated as just a little good with a score of 6.3±0.87. The inclusion of the flavour base increased the acceptability of weaning foods. Babies preferred products with an acceptable flavour and sweetness

4. Discussion

Several strategies can be applied to overcome the nutrient deficiencies and malnourishment among children. Food-based approaches are one among them. Complementary feeding mixes that are high in protein, fat and other vital nutrients can be developed using a combination of cereals and pulses along with plant and animal proteins. Four weaning food mixes exhibited a high rate of acceptance concerning sensory and nutritional quality. Millets have numerous nutritional qualities and are called nutri-cereals (Hulse J H *et al*., 1980) [11]. The results of the chemical analysis confirm that moisture, protein and fat values were within the range of values prescribed by FSSAI, 2006 [8]. Weaning food mix 3 was identified with the highest amount of protein (19.15 per cent) among the four mixes. The energy values (384.91 Kcal/100g to 392.62 Kcal/100g) of the mixes were adequate for the exceeded energy requirements of a child.
The viscosity of the barnyard millet based weaning food mixes was in the range 29162±108.9 cP to 398.7±17.9 cP, whereas the viscosity of the commercial weaning food formulation ranged between cP 4589.8±356.9 to 1517.4±89.7 cP at shear rates ranging from 0.3 to 60 rpm. The high viscosity values of the weaning food mixes at very slow rotational speeds may be due to the differences in dispersion, concentration and hydration property of various ingredients. Various other factors can influence the viscosity like pH, temperature, shear rate, and heat treatments during the manufacturing process (McCarthy, Singh. 2009) [14]. The protein present in the mix will undergo swelling and unfolding when dispersed in water which may increase the viscosity and also cause shear thinning behavior of the solution (Kinsella, Morr. 1979, McCarthy, Singh. 2009) [12, 14]. Studies by Cichero &Nicholson 2013 reported that the addition of thickeners increases the viscosity (Cichero &Nicholson 2013) [7]. Reports by Kinsella, 1979; Kinsella and Morr, 1984; McCarthy and Singh, 2009 stated that infant formulas exhibit pseudoplastic flow behavior. Fluids exhibit shear thinning over a wide range of shear rates which is a characteristic of fluid milk and protein dispersions containing casein, whey protein, soy protein, etc. This behavior was observed in this study. The high viscosity values of the weaning food mixes are due to the presence of protein and starch. Starch absorbs water on cooking forming a gelatinous mass. Barnyard millet is the major source of starch and soybean a major source of protein. Slight variations in the values are due to the differences in the proportions of each ingredient. At a higher rotational speed of 60 rpm, the viscosities of the weaning food mixes decreased than that of the commercial weaning food formula. A low viscosity value with high nutrient content is a desirable

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characteristic of weaning foods (Ariahu et al., 1999) [2]. This low viscosity value indicates the appropriateness of all the four weaning food mixes for feeding infants.

Evaluation of texture is an important criterion for assessing the overall quality of food products. As an alternative to sensory evaluation, several instrumental analysis was used for measuring the textural parameters. Based on the texture profile analysis significant difference in adhesiveness and stringiness of weaning food mixes and commercial infant formula can be observed. The textural properties of the weaning foods were influenced by the properties of ingredients. It has been reported that stringy, gummy and slimy foods are rejected (Szczesniak, 2002) [19] and the developmental stages of a child influence what texture are accepted or rejected (Szczesniak, 1972) [18] (Lundy et al., 1998) [13]. Infants start with liquid foods, and around ten months of age, teeth will develop and movement of chewing begins. Infants reject difficult to chew textures than toddlers. Infants prefer pureed foods. The texture profile analysis of the four weaning food formulations revealed that the parameters measured are convenient for six to twelve-month-old infants to consume without difficulties.

Sensory evaluation is simple in its principle, but the implementation is complex. Sensory qualities of the weaning foods corresponding to food preference of children are of great significance. Four different formulations of the weaning food mixes prepared were accepted by the children. Sensory acceptability of all the four weaning food mix ranged from 6.3±0.87 to 8.52± 0.84. It shows that weaning food mix 2 was the most accepted product and weaning food mix 4 was the least accepted product. The incorporation of flavour base in the mixes 2, 3 and 4 could be mentioned as an important factor that contributed the acceptability of the products.

5. Tables and Figures

Table 1: Proximate composition of Weaning food mixes

Samples	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

1. Values are means of three replicates ± SD

Table 2: Texture profile analysis

S.No	Sample	Adhesiveness (J)	Stickiness (g)	Stringiness (mm)	Resilience
1	Cerelac	1.03±0.07c	-4.33±0.57a	0.91±0.16c	0.34±0.08b
2	Weaning food mix 1	0.18±0.05b	-3.33±0.57a	0.09±0.03b	0.09±0.03b
3	Weaning food mix 2	1.25±0.12b	-16.00±1.73a	1.09±0.03b	0.52±0.04b
4	Weaning food mix 3	0.05±0.02b	-3.00±1.00a	0.61±0.50b	0.07±0.05b
5	Weaning food mix 4	0.43±0.28b	-3.67±0.57a	0.29±0.21b	0.11±0.02b

1. The values are means of triplicate determinations.
2. Means with different superscripts within the same columns are significantly different from each other ($p < 0.05$).

Table 3: Viscosity at different shear rates

Sample	Viscosity (cP)							
	0.3 rpm	0.6 rpm	1.5 rpm	3 rpm	6 rpm	12 rpm	30 rpm	60 rpm
Cerelac	4590.0 ± 356.55e	4756.7 ± 347.9e	3969.5± 255.3d	3469.3± 155.2c	2826.6± 147.3b	2751.5± 136.1b	1896.4 ± 117.6a	1517.4 ± 89.7a

Weaning food mix 1	27542 ± 1385.6f	21314 ± 1290.1e	12885 ± 501.4d	9394.7± 431.9c	4143.5± 589.0b	1697.1± 143.7a	932.1 ± 40.7a	432.5 ± 4.0a
Weaning food mix 2	28478 ± 1187.1g	27173 ± 1279.3f	18510 ± 990.5e	9768.9± 365.4d	4327 ± 356.8c	2323.0± 245.9b	711.5 ± 32.0a	440.5 ± 13.8a
Weaning food mix 3	29162 ± 108.9g	25304 ± 1238.9f	17167 ± 887.3e	8491.1± 224.9d	3343.1± 313.7c	1643.7± 117.9b	994.7 ± 135.4ab	439.1 ± 11.6a
Weaning food mix	26752 ± 117.9g	24003 ± 1048.1f	15682 ± 655.0e	7432.3± 348.9d	2894.6± 563.2c	1431.7± 128.9b	634.6 ± 89.0ab	398.7 ± 17.9a

1. The values are means of triplicate determinations.

2. Means with different superscripts within the same columns are significantly different from each other ($p < 0.05$).

Table 4: Sensory scores of weaning food mixes

Weaning food mixes	**Acceptability score**
Weaning food mix 1	6.5±0.64
Weaning food mix 2	8.52±0.84
Weaning food mix 3	8.25±0.54
Weaning food mix 4	6.3±0.87

1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
								
Super bad	Really bad	Bad	Just a little bad	May be good or bad	Just a little good	Good	Really good	Super good

Fig. 1 Nine point facial hedonic scale.

6. Conclusions

The incorporation of barnyard millet and soybean in weaning food formulations yield products with improved functional characteristics, high nutritive value and better acceptability. All the four weaning food mixes were characterized by acceptable viscosity, texture, and calories to meet the daily energy requirement of children. The procedure for preparing barnyard millet based weaning food mixes is easy and inexpensive compared to the commercial infant formulas

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