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Formulation and standardization of millet based supplementary food and its Physico-chemical evaluation

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Abstract
Wheat, ragi and bajra based supplementary food mix was prepared with 5.0 per cent incorporation of carrot and araikeerai (*Amaranthus dubius*) powder. Based on the organoleptic evaluation it was decided to use bajra based supplementary food mix for the further formulation of supplementary foods and its quality evaluation. The freshly prepared supplementary food mix contained moisture (5.96%), protein (15.85%), fat (9.85%), total sugar (14.10%), reducing sugar (8.65%), fiber (3.26%) and ash (2.04%). The calcium, iron, β-carotene, antioxidant activity and total chlorophyll of the food mix were 490.2 mg, 9.13 mg and 8,048 µg, 76.9 and 2.30 per cent, respectively. The pH and acidity of the sample were 6.20 and 0.507 per cent, respectively. The bacterial, yeast, fungal population of the supplementary food mix was 3.0 x 10^5 cfu / g, 4 x 10^5 cfu / g, 2 x 10^5 cfu / g, respectively.

Keywords: Millet, bajra, supplementation, β-carotene, organoleptic

Introduction
India is one of the biggest producer and consumer of millets in the world. In India, different types of millets including pearl millet, sorghum, finger millet and small millets such as barnyard millet, little millet, kodo millet, foxtail millet and proso millet are consumed. Because of their high nutritive value now millets are also called as 'Nutri-cereals'. In case of India, during 1965-66 these crops were cultivated in 36.90 million ha, producing 16.4 million tones grains, but in 2017-18 cultivation area was decreased to 14.25 million ha around 61.4% of reduction which produced 16.4 million tones. Millets are significant sources of important nutrients like phosphorus, niacin, magnesium, manganese, potassium and iron and also a rich source of protein, lecithin, fiber, methionine, essential amino acids and vitamin E. Consumption of millet and its products is decreasing due to rapid rate of urbanization, the change in consumer habits [3]. The school going children are the most important segment of the society. They are the builders of the future of any nation. Malnutrition among school children is one of the most important health problems and it accounts for over half of the deaths occurring among young children of developing countries [12]. Malnutrition is mainly caused by inadequate intake of macronutrients and micronutrients. In India around 36% of children under 5 years of age are underweight and 58% of children between 6months to 5 years are found to be anaemic [20]. If micronutrient deficiencies are made good it will improve Intelligence Quotient (IQ) by 10-15 per cent; reduce maternal deaths by one third; decrease child mortality by 40 per cent; eliminate nutritional blindness and increase work capacity by 40 per cent [14]. Supplementary feeding programmes constitute the most promising and effective measures to overcome the nutritional problem among children and improve the quality of their performance in school. So there is an urgent need to promote healthy weaning practices and the consumption of nutritionally sound, low cost supplementary foods to prevent the development of nutritional deficiency among infants and young children in developing countries including South Asia. Supplementary foods provide those additional nutrients that are lacking in day to day meals. Hence an attempt was undertaken to formulate supplementary food mix and evaluate its physico-chemical characteristics.

Methods

Preparation of Supplementary Food Mix

The supplementary food mix was prepared on the basis of a standardized supplementary food, 'Kuzhandai Amudhu' composition17. Wheat, ragi and bajra based supplementary food mix was prepared. The wheat/ragi/bajra, Bengal gram, ground nut and jiggery are taken in the proportion of 30:20:15:25 and 5.0 per cent of carrot and araikeerai (Amaranthus dubius) powder were also incorporated. The flow chart for the preparation of bajra based supplementary food mix is given in fig.1.

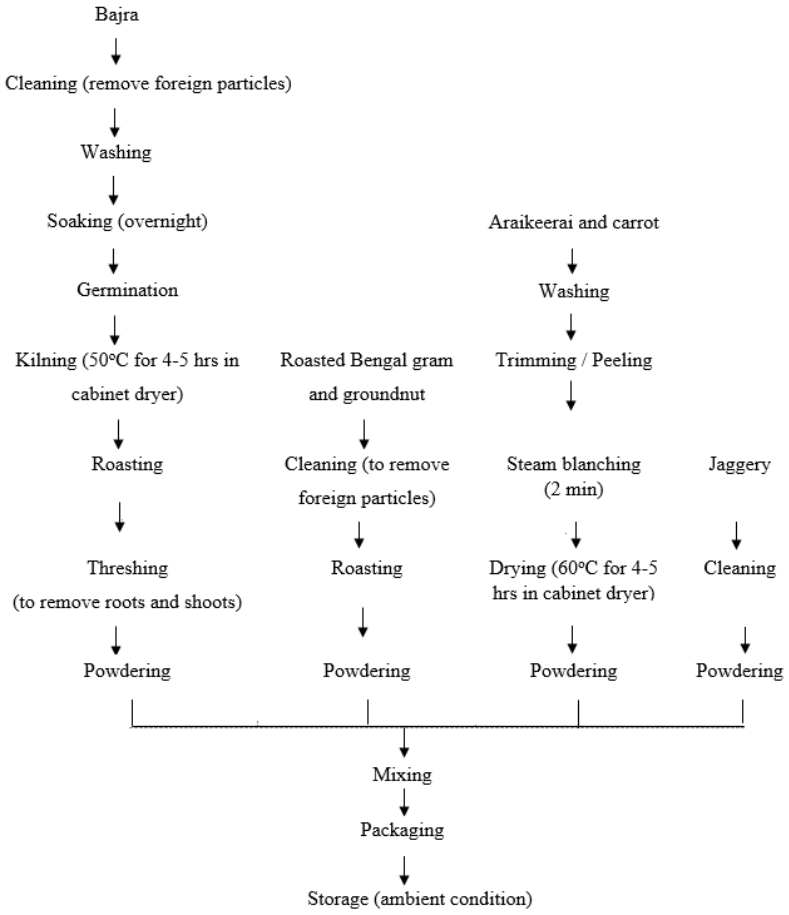

Fig 1: Flow Chart for the Preparation of Bajra Based Supplementary Food Mix

Development of products from supplementary food mix

Kozhukkatai

Supplementary food mix (100g) and grated coconut (25g) were mixed together and required quantity of water (30 ml) was added and made into thick dough. Divided the dough into small portion, pressed into oval shape and steamed it in idli cooker for 15 minutes.

Pittu

Supplementary food mix (100) was roasted till the raw flavour is removed. The roasted flour after cooling was moistened with little amount of water (15 ml) and mixed well to obtain bread crumb consistency. Steamed it in idli cooker for 15-20 minutes. Grated coconut (25 g) was added and served hot.

Roti

Supplementary food mix (100 g) was mixed well with 30ml of water and made it into thick dough. Divided the dough into small portions and made into small balls. Patted each dough ball into a flattened circle with wet fingers. Carefully removed the dough and placed on iron pan with little amount of oil (10 ml) and cooked till it became slight brown.

Biscuit

Supplementary food mix (100 g), baking powder (0.2 g) and cardamom powder (0.2 g) were mixed together, then sieved twice. Shortening (40 g) and powdered sugar (50 g) were creamed, blended with flour and made into dough. The dough was then rolled, biscuits were cut, baked at 160 °C for 15 minutes, cooled and evaluated for is proximate composition.

Physico-Chemical Analysis

Moisture, protein, fat, total sugar, reducing sugar, acidity, pH, β-carotene, ascorbic acid, crude fibre, total chlorophyll, antioxidant activity, total ash, calcium and iron were determined by AOAC method [2].

Organoleptic evaluation

The supplementary food mix were developed and the products like Kozhukkatai, Pittu, Rotti and biscuit were prepared and evaluated organoleptically by using 9-1 hedonic rating scale with the help of 15 semi-trained judges [19].

Microbial Examination

Approximately one gram of the sample was taken in a 9.0 ml sterile water blank and thoroughly mixed in a rotary shaker for 10 minutes. From the solution, a series of 10^6 to 10^3 dilutions were obtained by using serial dilution techniques. The dilutions 10^6, 10^4 and 10^3 were used for bacteria, fungi and yeast, respectively. From the respective dilutions, 1.0 ml of sample was poured in a petri dish. Appropriate medium

was prepared, sterilized and cooled (40 °C). The medium was poured into petri dishes and rotated clockwise and anticlockwise for uniform spreading of the medium, then allowed to solidify. After solidification, the plates were incubated at room temperature (28 ± 2 °C) for 24 to 48 hours for bacteria, 2 to 3 days for fungi and 5 days for yeast [10].

Cost analysis

Cost analysis of supplementary food mix and the products like *kozhukkatai*, *roti*, *pittu* and biscuits were calculated by taking into account the fixed cost and variable cost involved in the course of processing.

Statistical Analysis

The analysis of variance of the data obtained was done by using Completely Randomized Design (CRD). Critical differences were worked out at 5% probability level and presented [15].

Result and Discussion

Standardization of ingredients proportion based on organoleptic evaluation

The supplementary food mix was prepared by using different ingredients like cereals, pulses, nuts, greens powder, carrot powder and jaggery in the following proportion 30:20:15:5:5:25. Table 1 depicts the organoleptic evaluation of the supplementary food mix by using different ingredients. It was found that the ragi based supplementary food mix did not have an acceptable color and taste. The bajra based supplementary food mix scored better than the ragi and wheat based supplementary foods. From the bajra based supplementary food mix, the gingelly incorporation did not have an acceptable colour, because of its dark colour. The mean score for various parameters of the green gram and groundnut incorporation was better than the green gram and gingelly incorporation. The bajra, roasted bengal gram, groundnut, jaggery, greens powder and carrot powder in the ratio of 30:20:15:25:5:5 was highly acceptable and got maximum mean scores for all the parameters namely colour (9.0), flavour (8.0), texture (9.0), taste (9.0) and overall acceptability (9.0). Based on the organoleptic evaluation it was decided to use bajra based supplementary food mix for the further formulation of supplementary foods and its quality evaluation.

Table 1: Organoleptic evaluation of supplementary food mix

Ingredients proportions (30:20:15:25:5:5)	Colour and appearance	Flavour	Texture	Taste	Overall acceptability
Wheat based					
W:GG:Gr:J:G:C	9.0	8.0	9.0	8.0	8.0
W:RBG:Gr:J:G:C	9.0	8.0	9.0	8.0	8.0
W:GG:Gi:J:G:C	8.0	8.0	8.0	7.0	7.0
W:RBG:Gi:J:G:C	8.0	8.0	8.0	7.0	7.0
Bajra based					
B:GG:Gr:J:G:C	9.0	8.0	9.0	8.0	8.0
B:RBG:Gr:J:G:C	9.0	8.0	9.0	9.0	9.0
B:GG:Gi:J:G:C	8.0	8.0	8.0	7.0	8.0
B:RBG:Gi:J:G:C	8.0	8.0	8.0	7.0	8.0
Ragi based					
R:GG:Gr:J:G:C	6.0	8.0	8.0	8.0	7.0
R:RBG:Gr:J:G:C	6.0	8.0	8.0	8.0	7.0
R:GG:Gi:J:G:C	5.0	8.0	7.0	7.0	6.0
R:RBG:Gi:J:G:C	5.0	8.0	7.0	7.0	6.0
CD ($P \leq 0.05$)	0.317	0.402	0.308	0.331	0.389

W - Wheat, B - Bajra, R - Ragi, GG - Green Gram, RBG - Roasted Bengal Gram, Gr - Groundnut, Gi - Gingelly, G - Greens powder, C - Carrot powder, J – Jaggery.

Physico-Chemical Characteristics of Bajra Based Supplementary Food Mix

Physico-chemical characteristics of the bajra based supplementary food mix were studied and presented in table 2. The freshly prepared supplementary food mix contained moisture (5.96%), protein (15.85%), fat (9.85%), total sugar (14.10%), reducing sugar (8.65%), fiber (3.26%) and ash (2.04%). The calcium, iron, β-carotene, antioxidant activity and total chlorophyll of the food mix were 490.2 mg, 9.13 mg and 8,048 µg, 76.9 and 2.30 per cent, respectively. The pH and acidity of the sample were 6.20 and 0.507 per cent, respectively.

The infant weaning food developed by Nwanekezi and Okorie (2002) contained 10.3 g per cent of fat [13]. Subhanarayan, (1999) studied the initial pH of the weaning mix was 5.50 and the similar trend in pH was also observed in the present study [18]. Anand *et al*. (2001) reported that the crude fibre and total ash content of weaning mixes ranged from 2.03 to 2.51 and 2.97 to 5.12 g / 100g respectively [1]. Kanjana and Ramasaranya (2003) assessed the iron and calcium content of weaning mixes ranged from 4.50 to 6.65 and 32 to 347 mg / 100g, respectively [9]. Gupta and Sehgal (1991) reported the iron and calcium content of weaning foods between 17.75 and 19.42 and 150 and 190 mg / 100 g, respectively [7]. The supplementary food mix used for the study had recorded higher percentage of calcium than the values reported by other researchers. Gitanjali *et al*. [6] (2004) measured that the antioxidant activity of wheat *roti* and pressure cooked red gram dal were 79.50 and 77.45. More or less similar picture was noticed in the present investigation too.

Table 2: Physico-Chemical Characteristics of Bajra Based Supplementary Food Mix

Parameters	Quantity
Moisture (%)	5.96±0.11
Protein (%)	15.85±0.24
Fat (%)	9.85±0.17
Total sugar (%)	14.10±0.36
Reducing sugar (%)	8.65±0.09
pH	6.20±0.19
Acidity (%)	0.507±0.01
Crude fibre (%)	3.26±0.08
Total ash (%)	2.04±0.02
Calcium (mg / 100 g)	490.2±4.67
Iron (mg / 100 g)	9.13±0.01
β-carotene (µg)	8,048±109.51
Total chlorophyll (%)	2.30±0.03
Antioxidant activity	76.90±1.78

Physico-chemical changes during storage of bajra based supplementary food mix

Moisture

Changes in the moisture content of the supplementary food mix during storage is given in fig. 2. An increasing trend in the moisture content was noted during storage. The moisture permeable nature of the polyethylene bag and the presence of jaggery, which is highly hygroscopic could have attributed to the higher moisture content. The initial moisture content of the supplementary food mix was 5.96 per cent and it recorded a final moisture was 6.64 per cent. Kalai (1998) noted an increasing trend in the moisture content from 11.0 to 11.34 g per cent on storage (3 months) in the composite flour mix containing cereals and pulse flours[8].

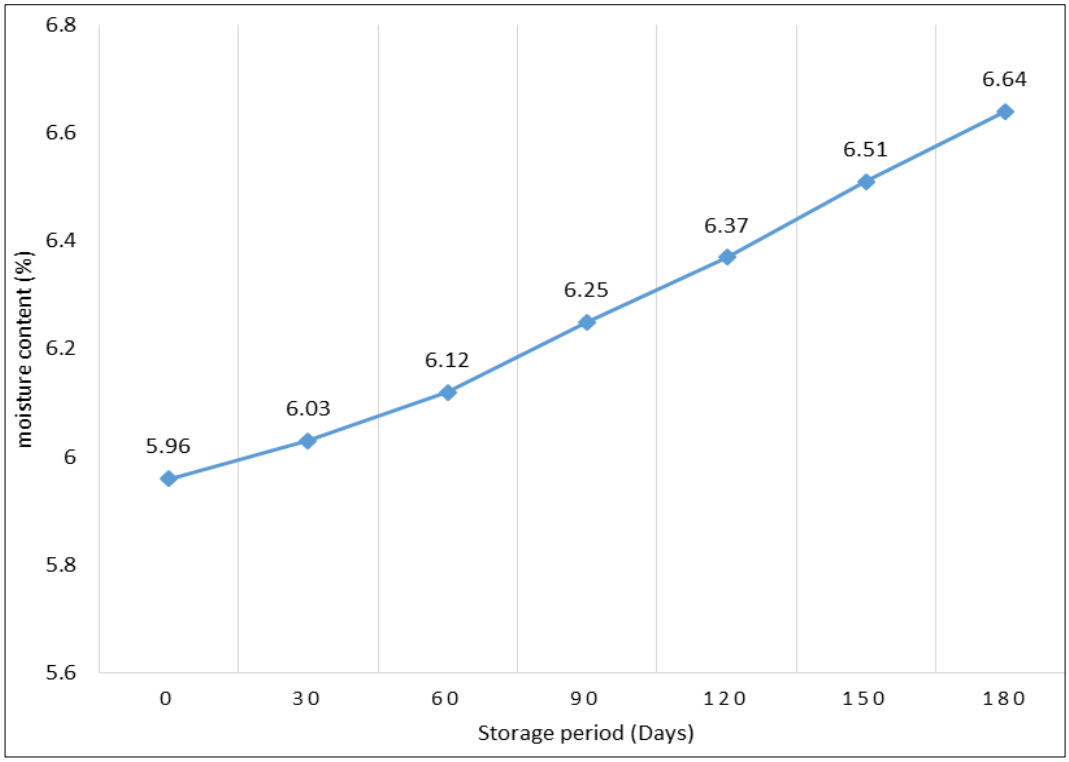

Fig 2: Changes in Moisture (%) during Storage

Total sugar

The data pertaining to the changes in total sugar content during storage is presented in fig.3. As the storage period increased the reduction in the total sugar content was also noted. The reduction in total sugar content may be due to the utilization of sugars in non-enzymatic browning reaction occurring during storage. Initially supplementary food mix had 14.10 per cent of the total sugar. At the end of 180 days the values of the total sugar was decreased to 12.43 per cent. Statistical analysis showed that there was a significant difference in total sugar content between the storage periods. Ranipadmini and Banumathi (2005) noted that the initial sugar content was in range of 11.87 to 12.70 g per cent [16]. During storage, the supplementary food also exhibited a loss in the total sugar content of samples after 180 days of storage. Similar picture was noted in the present investigation too. Chitra (2000) observed that there was a decreasing trend in the total sugar content of banana soya blended weaning food mix during storage[5]. The present study also showed similar picture among stored sample.

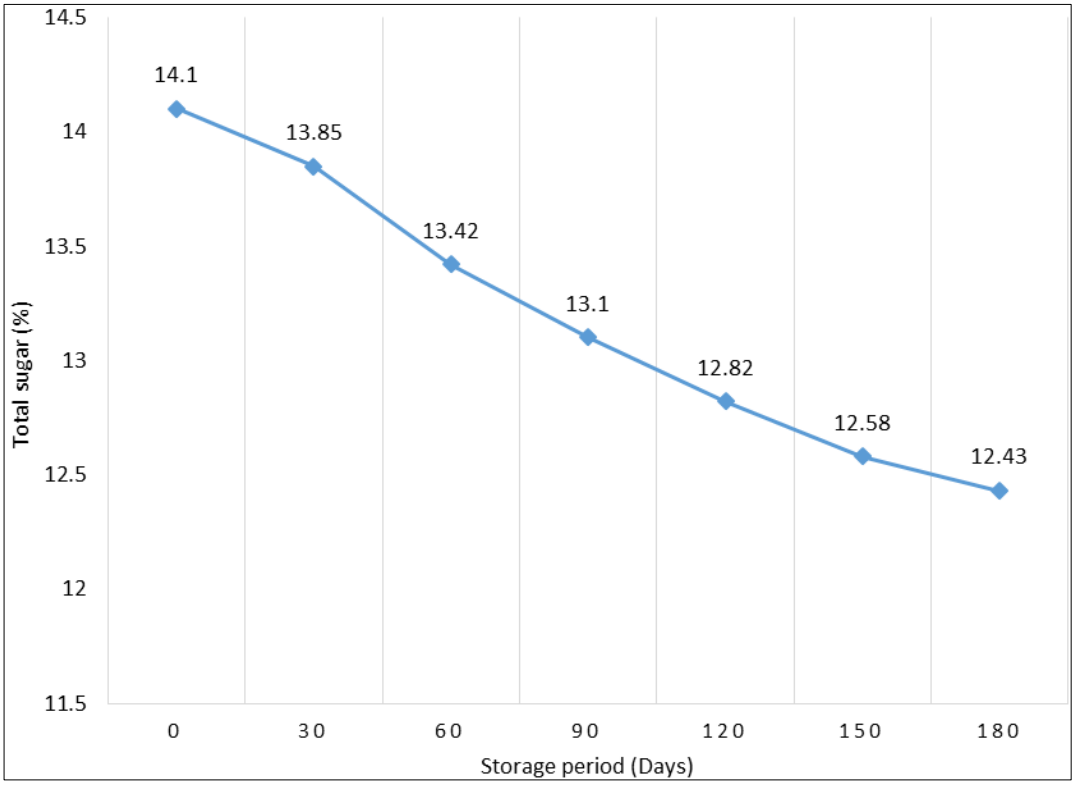

Fig 3: Changes in total sugar (%) during Storage

Reducing sugar

Fig.4. represents the changes noted in the reducing sugar content of supplementary food mix during the study period. The supplementary food mix exhibited an increasing trend in reducing sugar during storage. The freshly prepared supplementary food mix contained 8.65 per cent of reducing sugar, whereas at the end of storage period, the supplementary food mix had increased to 10.81 per cent. Manan *et al*. (1998) reported a reducing sugar level of 6.5 to 11.0 g per cent in jaggery based amaranth sweet meat [11]. Subhanarayan (1999) stated that there was an increasing trend in reducing sugar content of malted wheat flour and skim milk powder based weaning mix during storage. Similar situation was observed in the present investigation too [18].

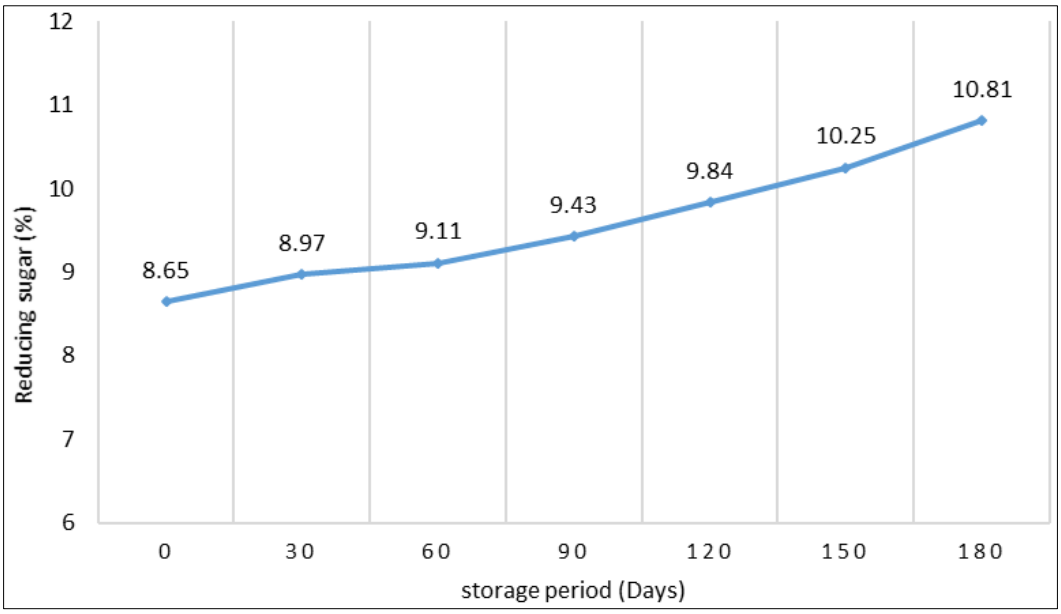

Fig 4: Changes in reducing sugar (%) during Storage

Organoleptic evaluation of supplementary food mix during storage

The organoleptic characteristics *viz*., appearance, colour, flavour, texture, taste and overall acceptability of the supplementary food mix were recorded every month during the period of storage by a panel of 15 semi trained judges with 9-1 hedonic scale. The Colour, Flavour, texture, tastes and overall acceptability of supplementary food mix was highly acceptable during the storage period. The organoleptic score of freshly prepared supplementary food mix was 9.00 whereas at the end of storage period, the score decreased to 7.50 (fig.5).

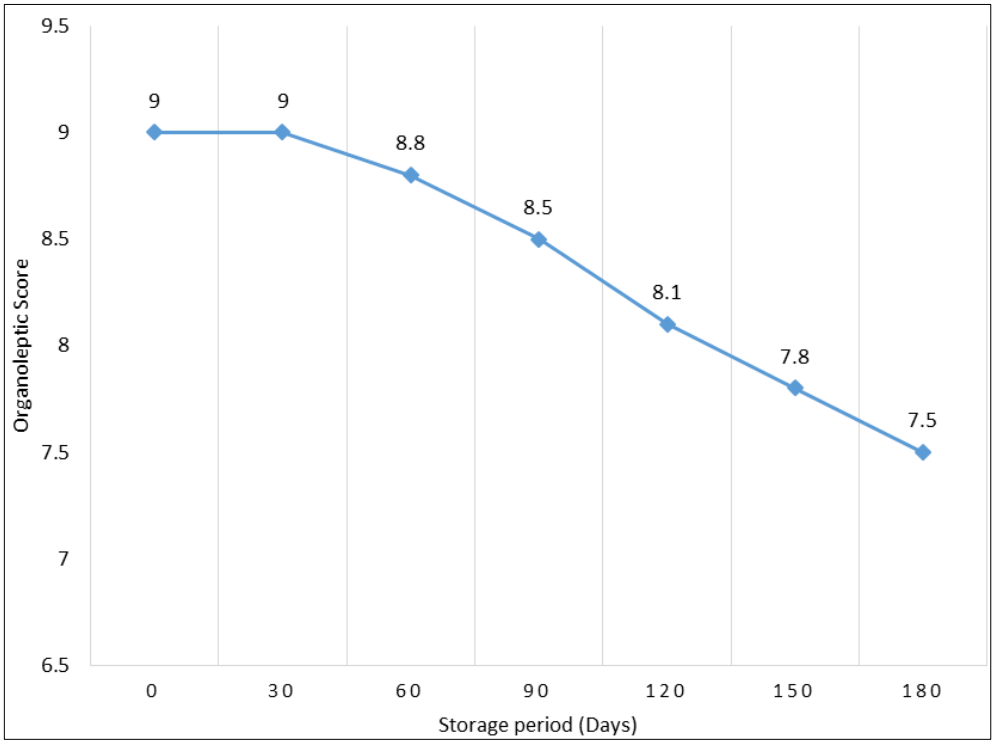

Fig 5: Changes in organoleptic score during Storage

Organoleptic evaluation of the products prepared from supplementary food mix

Pittu and biscuits secured high organoleptic score than the other products (Table 3). The texture of all the products was highly acceptable. The Colour of all the products ranged from 7.0 to 8.0. The Flavour of the products ranged from 8.0 to 9.0. The taste of the products was observed between 7.0 to 9.0 and overall acceptability ranged from 8.0 to 9.0.

Table 3: Organoleptic characteristics of products prepared from supplementary food mix

Products	Colour	Flavour	Texture	Taste	Overall acceptability
Supplementary food ball	7.0	8.0	9.0	8.0	8.0
Kozhukkattai	7.0	8.0	9.0	7.0	8.0
Roti	7.0	8.0	9.0	9.0	8.0
Pittu	8.0	9.0	9.0	9.0	9.0
Biscuits	8.0	9.0	9.0	9.0	9.0

Microbial population of supplementary food mix

The microbial population of supplementary food mix were observed and preesented in fig.6. The bacterial, yeast, fungal population of the supplementary food mix was 3.0 x 10^5 cfu / g, 4 x 10^5 cfu / g, 2 x 10^5 cfu / g, respectively.

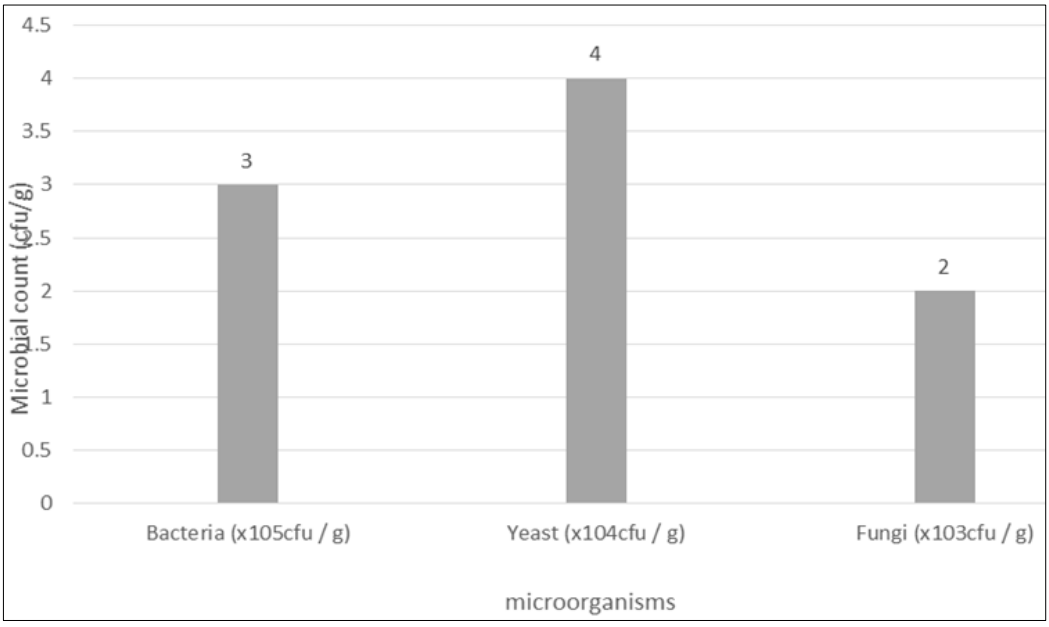

Fig 6: Microbial population in supplementary food mix

Cost analysis

The unit cost for the supplementary food mix and the products like *kozhukkatai, roti, pittu* and biscuits were Rs. 8.40, 8.50, 8.80, 8.50 and 13.30 respectively. The raw ingredients and the packaging materials used for the preparation of these products had influenced their final unit cost.

Conclusion

The bajra, roasted bengal gram, groundnut, jaggery, greens powder and carrot powder in the ratio of 30:20:15:25:5:5 was highly acceptable and got maximum mean scores for all the parameters namely colour, flavour, texture, taste and overall acceptability. The incorporation of greens powder and carrot powder enrich the iron and β-carotene content of the suppemetary food mix. The supplementary food mix can be used for the formulation of millet based nutritious food like Supplementary food ball, Kozhukkattai, Roti, Pittu and Biscuits.

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