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Formulation and quality evaluation of cereals, legumes and greens based nutritious mix

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Nutrition plays a vital role for normal growth and to maintain physical and mental fitness throughout the life. So the present study was undertaken with the objective to develop nutritious mix rich in protein and other nutrients using household technologies. The three different treatments of nutritious mixes was formulated from malted food grains (wheat, ragi, greengram and soybean) along with roasted sesame seeds, drumstick leaves powder and jaggery. The physical properties were observed that bulk density ranged from (0.697 to 0.736 g/ml), true density (1.08 to 1.21 g/ml), water absorption index (2.37 to 3.50 g/g), water solubility index (4.63 to 4.75%), oil absorption capacity (1.27 to 1.31 ml/g) and swelling power (2.71 to 2.89 ml/g). The prepared nutritious mixes were investigated for essential amino acids and sensory qualities. The chemical characteristics such as moisture, acidity, energy, crude protein, carbohydrate, starch, crude fat, β-carotene content of all the treatments (T_1,T_2 and T_3) ranged from 6.40 to 7.56g, 0.148 to 0.163g, 372 to 374.97 Kcal, 14.24 to 16.19 g, 59.18 to 62.56 g, 33.92 to 35.08 g, 7.16 to7.85 g, 3240.74to 3689.81 μg per 100 g. Among the different treatments ash, fibre, calcium, phosphorus and iron content ranged from 4.05 to 4.10 g, 2.69 to 2.81g, 374.68 to 379.47 mg, 305.68 to 311.27 mg and 5.17 to 5.53 mg/100 g. Physiochemical properties of the formulated nutritious mixes were within the acceptable at laboratory and field level, low cost and may contribute to alleviating child malnutrition.

Key Words : Germination, Malting, Nutritious mix, Physical properties, Chemical composition, Sensory evaluation

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INTRODUCTION

Protein energy malnutrition coupled with micronutrient malnutrition are the major public health problems in the developing countries. Nearly one in five children under age five in the developing world is underweight and it contains to be a primary cause of ill health and mortality among children (Prasot *et al.,* 2014). One in every three malnourished children of the world lives in India and under-nutrition is a major cause in more than half of under five deaths (www.unicef.org). Malnutrition has shown to be an important concern in children because of rapid growth and development. Poor feeding practices as well as lack of suitable supplementary foods are responsible for under nutrition with poverty exacerbating the whole issue. The supplementary foods are often of low nutritional quality and given in insufficient amounts when introduced too early or too frequently, they displace breast milk as the main sources of nutrition in infants.

Fortified nutritious commercial supplementary

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foods are unavailable especially in the rural areas and where available, they are often too expensive and beyond the reach of most of families in India. Therefore, most supplementary foods used are locally produced and based on local staple foods, usually cereals that are processed into porridges. Apart from their bulkiness reported as a probable factor in the etiology of malnutrition, cereal based gruels are generally low in protein and are limiting in some essential aminoacids. Supplementation of cereals with locally available legumes rich in protein and although, often limiting in sulphur aminoacids, increases the protein content of cereal-legume blends and their protein quality through mutual complementation of their individual aminoacids. Modification of traditional preparations like supplementary food which are incorporated with leafy vegetables could serve as a means of enhancing nutritive value of food (Helland *et al.*, 2002). As green leafy vegetables are good sources of micronutrients, incorporation of dehydrated drumstick leaves was envisaged to add value to the supplementary foods in terms of nutrition and sensory appeal. The present investigations were carried out to formulate and develop low cost supplementary food for children of Tamil Nadu by using available resources. The effect of malting present in the formulated nutritious mixes on the physical properties nutritional components and sensory quality characteristics were analysed.

METHODOLOGY

Materials :

Wheat, ragi, green gram, soybean, sesame seeds, drumstick leaves and jaggery were procured from the local markets in Madurai, Tamil Nadu. For the purpose of the study nutritious mixes were developed by mixing different staples and drumstick leaves added as micronutrient supplements and jaggery were added as energy supplements and labelled as T_1 T_2 and $T_{3,}$ to improve the sensory attribute of the developed mixes.

Preparation of the nutritious mixes :

High quality cereals and legumes were carefully selected, sorted and cleaned to remove the foreign materials. Wheat, ragi, green gram and soybean were soaked overnight for germination. They were tied by using muslin cloth, allowed for germination at room temperature. Germination was done to increase digestibility, bioavailability of vitamins, minerals, proteins and decrease anti nutrients and starch. The germinated cereals and legumes were again washed and dried in the cabinet drier under controlled temperature (50-60°C). The temperature was maintained for 6 hours for drying and periodic turning of the grains were done to ensure uniform drying. The dried grains were devegetated by rubbing them against a hard surface and removed by winnowing. Kilning was done by mild toasting of the malted grain to obtain a pleasant flavour and aroma. The dried and cleaned sesame seeds were roasted at 70-75°C till the development of colour and flavour.

Fresh drumstick leaves were destalked and washed thoroughly in running tap water to remove the unwanted impurities. And then steam blanched for three minutes by using idli pan. The steamed drumstick leaves were dried in a cabinet drier for four hours under the controlled temperature of 30-40°C. The above prepared food materials were milled to make flour for nutritious mix preparation.

Nutritious mix formulae development :

Three types of nutritious mixes were formulated by using wheat, ragi, greengram and soybean in the germinated form along with roasted sesame seeds, drumstick leaves powder and jaggery. The malted cereals and legumes flours used in the different ratios 30:30, 35:25, 40:20 and developed the nutritious mix. Further sesame seeds powder (5%), drumstick leaves powder (5%) and jaggery (25%) was kept constant. The proportions and composition of the nutritious mixes $T_{1,}$ T_2, and T_3 that were formulated are shown in (Table A).

Physical properties :

Bulk density :

The bulk density was determined according to the method described by Okaka and Potter (1979). 50 gram of sample was put into a 100ml graduated cylinder. The cylinder was tapped 40 to 50 times and the bulk density was calculated as weight per unit volume of sample. Bulk density = weight of flour (g)/ volume of the bulk flour (cm^3)

True density :

Hundred ml of volumetric flask was taken and measure its weight (W_1). Then fill the flour upto the mark on the volumetric flask. Find out the weight again (W_2).

Table A : Composition of formulated nutritious mixes

Formulation Name	Ingredients (g)						
	Malted wheat	Malted ragi	Malted greengram	Malted soybean	Roasted sesame seeds powder	Dried drumstick leaves powder	Jaggery
T_1	15	15	15	15	10	5	25
T_2	15	20	15	10	10	5	25
T_3	20	20	10	10	10	5	25

Then pour the measured oil into the volumetric flask. Then take weight (W_3). Difference between them gives the actual weight of the flour $W_3 - (W_2 - W_1)$. The true density was calculated by the following expression (Poongodi and Mohankumar, 2009).

True density = weight ($W_2 - W_1$) / actual volume – void volume

Water absorption index (WAI) and Water solubility index (WSI) :

Water absorption index and Water solubility index were measured according to the method of Anderson *et al*. (1969). The 2g of nutritious mix sample was dispersed in 25 ml of distilled water, taking care to break up any lumps using a glass rod. It was allowed to shake in a rotator shaker for 30 min and dispersions were rinsed into tarred centrifuge tubes and then centrifuged at 5000rpm for 10 min. The supernatant was decanted for determination of its solid content and the sediment was weighed. WAI and WSI were calculated by the following expression

WAI = weight of sediment / weight of dry solids

WSI = weight of dissolved solids in supernatant × 100 / weight of flour sample

Oil absorption capacity :

The oil absorption capacities were determined by the method of Sosulski *et al.* (1976). One gram sample was mixed with 10 ml oil and was allowed to stand at ambient temperature (32°C) for 30 min. Then centrifuged for 30 min at 2000 × g. Oil absorption capacity was expressed as oil bound per gram flour. Oil capacity of the flour = weight of oil absorbed (ml) / weight of sample (g).

Swelling power :

Swelling power was determined through the method described by Leach *et al*. (1959). One gram of sample was mixed with 10 ml distilled water in a centrifuge tube and heated at 80°C for 30 min. This was continually shaken during the heating period. After heating, the suspension was centrifuged at 1000 ×g for 15 min. The supernatant was decanted and the weight of the paste was taken. The swelling power was calculated as swelling power = weight of the paste / weight of dry flour.

Determination of proximate composition :

The moisture and acidity contents were determined by Ranganna (1995). Nitrogen content was determined using micro-kjeldhal and converted to crude protein (N × 6.25). The crude fat was estimated by exhaustive extraction with petroleum ether (B.P. 40 to 0°C) using a soxhlet apparatus (AOAC, 2004). The carbohydrate, crude fibre and starch were estimated by the method described by Sadasivam and Manickam (2008), while food energy was calculated by multiplying the values of crude protein, crude fat and carbohydrate by factors of 4, 9 and 4, respectively finding the sum of their products and expressing, the result in locations (Livesey, 1995). The ash obtained after combustion in the muffle furnace was used to prepare the ash solution, which was in turn used for the estimation of mineral contents (AOAC, 1995 and Ranganna 1995) such as calcium, phosphorus and iron. The β carotene content was measured colorimetrically at 453 nm in colorimeter (Ranganna, 1995) and it was expressed as µg per 100 g of nutritious mix.

Amino acid profile :

Amino acid profile was evaluated as per the procedure described by Bidilingmeyer *et al*. (1987). Samples were hydrolyzed in two different flasks according to AOAC method 994.12. Nor. Leucine was spiked into the samples prior to hydrolysis to monitor the efficiency and recovery of the entire analytical procedure. After hydrolysis, the hydrolysate was diluted 5 times with double distilled water and 10 µl of the solution being transferred to an Eppendorf tube, dried in vacuum. Direct hydrolysis of samples was carried out with 6N HCl to obtain hydrolysates suitable for analysis of all amino acids. Hydrolysis was carried out by adding 4.0 ml of double distilled 6N HCl to 20 mg of sample in dry test tubes. Hydrolysis of samples was carried out at 110°C for 24 hours in a forced-draft oven. After hydrolysis, HCl was removed from the hydrolysate mixture by placing the test tubes in desiccator containing NaOH pellets and evacuating to approximately 1 mm. This vacuum is necessary to ensure that the HCl is removed within 10 hours. Citrate buffer (25 ml, 0.20 N, pH 2.2) containing Brij-35 detergent and octonic acid was added to the residue. Aliquots of supernatant or filtrate were then used for amino acid analysis. Amino acids were analyzed with a Beckman-Spinco model 120 amino acid analyzer and a 2 mm cuvet were used. Type PA-27 resin was used for the separation of all basic amino acids. The identity of amino acids was checked with standard amino acids. Results were obtained as chromatograms and in a report with table of picomoles of each amino acid and total amount in milligrams per 100g of sample.

Sensory quality of the nutritious mixes :

To find out the most acceptable nutritious mix for sensory quality were evaluated using 'nine point hedonic scale' (1-9). Sensory quality was evaluated in a sensory evaluation room. The gruel prepared from the samples and served to panel of twenty judges comprising of students and staffs who were very familiar with gruels made from nutritious mix. The panelists were asked to score each sample on a 9 – point hedonic scale, where 1 and 9 represent dislike extremely and like extremely, respectively. The sensory quality attributes *viz*., colour, flavour, texture, appearance and overall acceptability were studied by score card method (Amerine *et al.*, 1965).

Statistical analysis :

The analysis was carried out in three replicates for all determinations. The mean and standard deviation of means were calculated. Factorial Completely Randomized Design (FCRD) as per method described by Gomez and Gomez (1984) were employed for analysis of data at 0.05 level of significance.

OBSERVATIONS AND ASSESSMENT

Malnutrition is an insufficient or excessive or imbalanced consumption of nutrients. The net effect of this condition in the developing countries is manifested in the prevalence of various forms of protein energy malnutrition diseases such as kwashiorkor, marasmus and marasmic kwashiorkor. To compensate the nutrient deficiencies of children, supplementary foods need to be developed from low cost and locally available foods such as cereals, legumes and green leafy vegetables. Therefore, an attempt was made to develop nutritious mix by using wheat, ragi, soybean and greengram and as malted along with sesame seeds, drumstick leaves powder and jaggery for enhancing the nutrient content. The mix was formulated at different ratios *viz*., T_1 (15:15:15:15:10:5:25), T_2 (15:20:15:10:10:5:25) and T_3 (20:20:10:10:10:5:25). These three combinations are mixed only changes in cereals and pulses to increase the carbohydrate and protein content of the mix. To combat the problem of under-nutrition, the mixing ratios (cereals : legumes) were formulated to contain enough energy and protein to meet the daily requirements of infant from 6 month of age.

Proximate composition of raw materials:

The results on the proximate analysis of the different ingredients which were used in the formulation of the nutritious mix comprising of (raw and malted) selected food grains are presented in (Table 2). The moisture content of malted food grains and dried drumstick leaves ranged from 4.27±0.08 to 11.66±0.23 g per 100 g. Similar findings was reported by Karthika (2005) on during processing of food grains, the moisture content was observed to be reduced. Slight significant change was noted on fat, carbohydrate of processing food grains. Inyang and Zakari (2008) reported a significant decrease ($P<0.05$) in carbohydrate and fat levels on germination. The observed fat decrease might be due to the increased activity of the lipolytic enzymes during germination, which hydrolyse fats to free acids and glycerol. The increase in respiration rate during germination brings about the release of energy from the breakdown of the carbon compounds. Germination changes the stored insoluble nutrients in the cotyledons to soluble nutrients through the hydrolysis of macromolecules (Murugar *et al*., 2013). The decrease in carbohydrate might be due to increase in alpha amylase activity. The alpha amylase breaks down complex carbohydrates to simpler and more absorbable sugars which are utilized by the growing seedlings during the early stages of germination.

Germination increased the protein content moderately in wheat, ragi, greengram and soybean (Ikujenlola, 2008). The protein content was increased in malted food grains compared to unmalted grains. The increase in protein content on germination of seeds was due to mobilization of storage nitrogen thus producing nutritionally high quality proteins which is essential to meet the young plant needs for development. Similar trend was noted in the present study also. The increase seen could be due to a compensatory increase in free amino acids and peptides and increase in non-protein

Table 1 : Proximate composition of food materials

Particulars	Moisture (g)	Protein (g)	Fat (g)	Carbohydrate (g)	Calcium (mg)	Iron (mg)	β-carotene (μg)
Wheat	12.35 ± 0.35	12.85 ± 0.26	1.30 ± 0.03	70.75 ± 1.42	39.25 ± 0.79	4.51 ± 0.09	-
Ragi	11.94 ± 0.23	7.52 ± 0.15	1.27 ± 0.03	69.97 ± 1.40	335.12 ± 6.70	4.74 ± 0.13	-
Greengram	10.36 ± 0.21	22.42 ± 0.45	1.50 ± 0.04	54.42 ± 1.09	112.05 ± 2.24	4.31 ± 0.09	-
Soybean	9.16 ± 0.01	39.17 ± 0.78	18.35 ± 0.03	19.75 ± 0.40	231.69 ± 4.63	9.45 ± 0.19	-
Gingelly seeds	5.13 ± 0.11	17.26 ± 0.35	37.60 ± 0.75	24.00 ± 0.48	1423.20 ± 28.46	8.58 ± 0.17	37.00 ± 0.74
Malted wheat	11.66 ± 0.23	13.67 ± 0.27	1.25 ± 0.03	70.73 ±1.41	39.32 ± 0.79	4.55 ± 0.09	-
Malted ragi	10.72 ± 0.21	8.75 ± 0.18	1.22 ± 0.02	69.93 ± 1.40	335.21 ± 6.70	4.78 ± 0.13	-
Malted greengram	9.48 ± 0.19	23.88 ± 0.48	1.47 ± 0.03	54.37 ± 1.09	112.12 ± 2.24	4.36 ± 0.09	-
Malted soybean	8.35 ± 0.17	40.23 ± 0.80	18.30 ± 0.03	19.71 ± 0.39	231.77 ± 0.40	9.48 ± 0.19	-
Roasted gingelly seeds	4.27 ± 0.08	17.26 ± 0.35	37.54 ± 0.75	23.96 ± 0.50	1423.18 ± 28.46	8.57 ± 0.17	31.40 ± 0.63
Dehydrated and powdered drumstick leaves	6.36 ± 0.13	13.38 ± 0.11	2.85 ± 0.03	16.37 ± 0.23	1543.58 ± 8.87	7.29 ± 0.01	18537. 76±1 44.28

The values are expressed as the mean of three replicate samples ± standard deviation

Table 2 : Physical properties of the nutritious mixes

Particulars	T_1	T_2	T_3	P value
Bulk density (g/ml)	0.709±0.01	0.697±0.01	0.736±0.01	0.0387*
True density (g/ml)	1.18±0.02	1.08±0.02	1.21±0.02	0.0011**
Water absorption index (g/g)	3.39±0.07	3.50±0.07	2.37±0.04	9.95 ^{NS}
Water solubility index (%)	4.75±0.50	4.67±0.47	4.63±0.49	0.0015**
Oil absorption capacity (ml/g)	1.31±0.03	1.27±0.03	1.30±0.03	0.2236 ^{NS}
Swelling power (ml/g)	2.89±0.06	2.78±0.06	2.71±0.05	0.0208*

The values are expressed as the mean of three replicate samples± standard deviation, * - Significant, ** - Highly significant, NS=Non-significant

Table 3 : Proximate composition of the nutritious mixes

Chemical constituents	T_1	T_2	T_3	SED	CD (0.05)
Moisture (g)	6.44	7.56	6.40	0.0270	0.0536**
Acidity (g)	0.163	0.150	0.148	0.0005	0.0011**
Crude protein (g)	16.19	14.93	14.24	0.0537	0.1064**
Carbohydrate (g)	59.18	61.97	62.56	0.2181	0.4316**
Starch (g)	34.17	33.92	35.08	0.1222	0.2419**
Crude fat (g)	7.85	7.16	7.20	0.02604	0.0515**
β-carotene (μg)	3359.56	3240.74	3689.81	12.1266	23.9984**
Energy (Kcal)	374.97	372.04	372.00	0.0192	0.0471**
Crude fibre (g)	2.81	2.73	2.69	0.0237	0.0581**
Ash (g)	4.08	4.05	4.10	0.0178	0.0437^{NS}
Calcium (mg)	374.68	379.47	376.53	0.0183	0.0447**
Phosphorus (mg)	311.27	305.68	310.16	0.0233	0.0569**
Iron (mg)	5.53	5.17	5.19	0.0221	0.0541**

** - Highly significant, NS=Non-significant nitrogenous constituents during germination. The dehydrated drumstick leaves had a β carotene content of 18537.76±1 44.28 µg/100g. Joshi and Mehta (2010) found the β carotene content of oven dried drumstick leaves powder had higher compared to fresh drumstick leaves. The mineral content of the malted food grains were increased slightly. The mineral content of the malted food grains were increased slightly. During sprouting, the activity of hydrolytic enzymes may lead to the release of more free calcium from its organic complexes. The results on the proximate analysis of the malted food grains showed similarities with findings presented by kulkarni *et al.* (2012).

Physical properties of the nutritious mixes :

The physical properties of the nutritious mixes are given in (Table 2). An important functional significance of bulk density is in the preparation of weaning food formulations. The bulk density of nutritious mixes ranged from 0.697 to 0.736 g/ml and found to be statistically significant ($P \geq 0.05$). Germination has been reported to be a useful method for the preparation of low bulk weaning foods (Imtiaz *et al.*, 2011). Bulk density is a measure of heaviness of flour and is generally affected by the particle size and the density of the flour (Nicole *et al.*, 2010). The low bulk density is an advantage because high bulk limits the caloric and nutrient intake per feed per child and infants sometimes are unable to consume enough to satisfy their energy and nutrient requirements.

The true density was noticed to be minimum in T_2 nutritious mix (1.08 g/ml). The difference in true density among the different treatments of the nutritious mixes *viz.*, T_1, T_2 and T_3 was statistically significant ($P \geq 0.05$). Water binding capacity measures the amount of water absorbed by starch and can be used as an index of gelatinization. It also depends on the availability of hydrophilic groups that bind water molecules and on the gel forming capacity of macromolecules (Onyeka and Dibia, 2002). The ability of the flour blends to absorb water is particularly important during reconstitution before consumption. The water absorption index (which indicate the volume of water needed to form a gruel with a suitable thickness for child feeding) of the T_1, T_2 and T_3 nutritious mixes was observed to be 3.39, 3.50 and 2.37 g/g, respectively. The difference in water absorption index among the different treatments of the nutritious mixes was statistically non-significant ($P \geq 0.05$). Nicole *et al.* (2010) reported that low water absorption capacity (2.27 ± 0.21 g/g) is desirable for making thinner gruels. The water absorbance capacities need to be low in order to produce more nutritious and suitable weaning foods. This could be achieved by reducing the viscosity of the starchy components by malting. Griffith *et al.* (1998) stated that the water absorption capacities are related to the starch and protein contents and the particle size distribution of the ingredients. Water solubility index increased by more than 100 per cent with malting, which can be attributed to increase in soluble sugars resulting from starch hydrolysis and changes in protein solubility properties. The water solubility index was found to be high in T_1 (4.75 %) followed by T_2 (4.67 %) and T_3 (4.63

Table 4 : Amino acid composition (mg/gN) of the nutritious mixes

Amino acid	Reference pattern (mg/g)	T_1	T_2	T_3
Lucine	66	76.40	36.80	27.00
Lysine	58	26.70	16.70	15.90
Methionine	25*	54.10	24.70	22.60
Phenylalanine	63**	92.80	44.80	32.80
Tyrosine		81.40	33.70	30.50
Alanine	-	6.70	3.10	2.70
Proline	-	18.50	90.20	71.70
Glycine	-	13.00	6.10	5.90
Arginine	-	98.10	32.10	30.50
Chemical score	-	7.85	4.91	4.68
Limiting amino acid (cereals)		Lysine	Lysine	Lysine
Chemical score	-	24.59	11.23	10.27
Limiting amino acid (pulses)		Methionine	Methionine	Methionine

FAO/WHO/UNU (1985) reference pattern (mg/g); * =Methionine + Cystine; ** = Phenylalanine + Tyrosine.

%). Statistical analysis revealed significant difference ($P \geq 0.05$) among the different nutritious mix T_1, T_2 and T_3.

Adetuyi *et al.* (2009) stated that the oil absorption capacity is a critical assessment of flavour retention and for increasing the palatability of foods and extension of shelf life. Statistical analysis revealed that the oil absorption capacity was not significantly different among the different treatments of nutritious mixes. The germinated grains were reported to enhance the oil absorbance capacity of the flours as the mechanism of oil absorption is a physical entrapment of oil related to the non polar side chains of proteins. Generally the water absorbance capacities of the weaning food formulations were systematically higher than their oil absorbance capacity. The swelling power values showed a significant difference ($P \geq 0.05$) among the different treatments which ranged between 2.71 and 2.89 ml/g. Emmanual *et al.* (2009) reported that the swelling power depends on the compositional structure of the sample. Sample with the least swelling index value would provide more nutrient density for an infant. The swelling power of the starch granules, leads to disruption of the intermolecular hydrogen bonds, thus allowing more water to enter and enlarge the granules. The swelling power of granules is an indication of the extent of associative forces within granule. It is often related to their protein and starch content.

Chemical composition of the nutritious mixes :

The results on the proximate analysis of the nutritious mixes are presented in (Table 3). The formulated nutritious mixes T_1, T_2 and T_3 contained moisture content 6.44, 7.56 and 6.40 g/100g, respectively. The acidity was found to be high in T_1, the value being 0.163 g/100g. The energy content of the nutritious mixes T_1, T_2 and T_3 samples ranged from 372.00 to 374.97 Kcal/100g. The carbohydrate content was maximum in T_3 (62.56 g/100g). According to the Indian Council of Medical Research (1981) the recommended optimal protein calorie requirement for pre-school going is 7.1 per cent in total mixed diets and all the formulation provided optimum recommended dietary allowance with respect to protein (10 to 12%) as recommended by World Health Organization (1985). Minimum protein content of 14 per cent has been prescribed for weaning foods by Indian Standard Specification (1969). The formulated nutritious mix had similar composition and was in conformity with the Indian Standard Specification. The results indicated that the formulations were adequate in protein for weaning purposes.

The starch, fat, ash and fibre content of the nutritious mix samples ranged from 33.92 to 35.08 g/100g, 7.16 to 7.85 g/100g, 4.05 to 4.10 g/100g and 2.69 to 2.81 g/100g, respectively. Addis *et al*. (2013) found that digestibility of starch in raw food grains were relatively poor, while compared by germination and kilning. Toasting of food grains increased digestibility of the starch. Higher digestibility of both starch and protein is an important characteristic of complementary foods. Ash content was highest in all the treatments of nutritious mixes, which may due to the presence of seed coat in the grains, as majority of the grains, were used along with the seed coat. The β-carotene levels in T_1, T_2 and T_3 were 3359.56, 3240.74 and 3689.81 μg/100g, respectively and it was increased in all the formulations with the addition of drumstick leaves powder. The calcium and phosphorus content for the samples ranged from 374.68 to 379.47 mg/100g and 305.68 to 311.27 mg/100g. The iron content was high in T_1 (5.53 mg/100g). The results indicated that there were significant differences between the formulated nutritious mixes in terms of nutritional characters.

Amino acid composition of the nutritious mix :

The amino acid profile of the nutritious mixes obtained during the present study is presented in (Table 4). The quality and functioning of a protein primarily depends on the composition of its essential amino acids. The nutritious mix T_1 recorded maximum values for leucine, lysine, methionine, phenylalanine, tyrosine, alanine, glycine and arginine which was 76.40, 26.70, 54.10, 92.80, 81.40, 6.70, 13.00 and 98.10 mg/gN followed by T_2 and T_3, respectively. The experimental

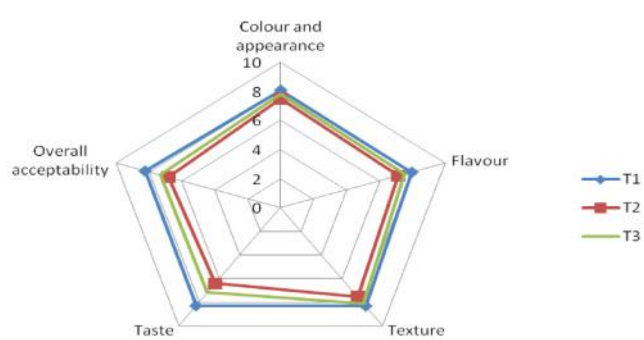

Fig. 1 : Sensory qualities of the nutritious mixes

values (T_1) were found closely similar and very good agreement with FAO/WHO/UNU (1985) reference values. FAO/WHO/UNU (1985) protein standard is an internationally accepted quality parameter for complementary food development.

Sensory quality of the nutritious mixes :

The mean scores of different sensory parameters of the nutritious mixes are shown in (Fig. 1). Appearance is important attribute in food choice and acceptance. Smell/flavour is an integral part of taste and general acceptance of the food before it is put in the mouth. It is therefore an important parameter when testing acceptability of formulated foods. Taste is an important parameter when evaluating sensory attribute of food. The formulated different treatments of nutritious mixes obtained the mean scores of overall acceptability T_1, T_2 and T_3 were 8.23 (like very much), 6.80 (like slightly) and 7.30 (like moderately), respectively. This indicates that 5 per cent drumstick leaves powder did not affect the sensory quality characteristics of the nutritious mixes.

Conclusion:

The present investigation was carried out to formulate a nutritious mix for poor people to fulfill their nutritional requirements at lower cost. It can be occluded that cereals, legumes and drumstick leaves incorporated nutritious mixes were highly nutritious and effectively used in the preparation of nutritious food items. From the results obtained it can be seen that sprouting/malting helps in increasing the nutritional components of the nutritious mixes which further enhanced their nutritional and physical properties. These mixes can be successfully used for supplementary feeding programmes. Already available mixes are not that much affordable and that too, no such mixes contains drumstick leaves. This mix is commercially accessible and can be easily prepared by locally available materials.

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