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The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; 12(4): 1691-1694

www.thepharmajournal.com
Received: 22-01-2023
Accepted: 26-02-2023

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Physiochemical evaluation of complementary foods mix formulated from functional ingredients

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Abstract
Complementary foods are mostly based on staple cereal or root crops. Although commercially available, complementary foods are often expensive and thus unaffordable to the nation's poor population (Muhimbula *et al.,* 2011). The present study aimed to formulate and evaluate the physiochemical properties and acceptability of complementary food. The complimentary food was formulated from rice flour, malted green gram flour, flaxseed powder, carrot powder and muskmelon seed powder in three different proportions, T1 (70:15:5:5:5), T2 (60:20:5:10:5) and T3 (65:15:5:10:5). Functional properties, sensory attributes and nutritional content of the formulations were evaluated. The product was easily dispersed in warm water and reconstitution had a smooth and homogeneous consistency. Physicochemical and sensory attributes of the formulated products were within the acceptable standard for children aged between 6 and 24 months. The nutrient composition of the products ranged from protein 10.38-11.31%, fat 4.19-4.36%, crude fibre 0.77-1.12%, Total minerals 3.28-3.67%, moisture 6.65-6.87%, carbohydrate 72.38-73.91% and energy 367.01-378.15 kcal/100 g. The complimentary mix also had good functional properties and was acceptable even after storage of 45 days. The newly developed complementary food may contribute to alleviating child malnutrition.

Keywords: Complementary foods, functional properties, sensory properties, nutritional content

Introduction
The World Health Organization (WHO) recommends exclusive breastfeeding for the first six months of life, with the addition of complementary feeds at six months with continued breastfeeds until the age of two (Riberio and Antunes, 2018) [27]. Infants and young children are at an increased risk of malnutrition from six months of age onwards when only mother milk is not enough to fulfil nutrient requirements complementary feeding should be started (NFHS-4, 2014-15). Initiating complementary feeds too early or too late lead to malnutrition. After 6 months of age, most infants are developmentally ready for other foods at about 6 months, infants should start receiving foods in addition to breast milk from 6 months onwards (Who, 2009) [34]. The complementary feeding period is the time when malnutrition starts in many infants contributing significantly to the high prevalence of malnutrition in children less than 5 years of age. The nutritional value of complementary food should fulfil the nutrient requirement of the rapidly growing child and the food should be diverse with appropriate texture and given in sufficient quality.

Poor infant feeding practices as well as childhood and maternal undernutrition are the major risk factors associated with infant and early childhood mortality and morbidity (WHO, 2010) [35, 37]. Unlike developed countries there are many children affected by obesity, most children in developing countries such as sub-Saharan Africa and southern Asia are conversely affected by an inadequate supply of nutrients. Millions of children in the developing world are borderline normal and may fall into the category of underweight at any time due to more or another cause of malnutrition unless timely and appropriate interventions are made. (Black *et al*., 2008; WHO, 2010) [4, 35, 37].

Dietary diversification, supplementation and fortification of locally available food could also result in improved micronutrient intake of infants and young children during the complementary feeding period. This study was part of an explanatory effort on the improvement of nutritional quality of traditional complementary food. It was designed to use staple food to formulate composite blends that can provide the needed nutrients for nourishing infants and children and are readily available and affordable to both rural and urban poor mothers in particular.

The main objective of the present study was therefore to formulate a reduced bulk nutrient-dense complementary food for children, characterize the food and study the nutritional and sensory acceptability of the product.

Materials and Method

Formulation of mix: The experiment work was carried out for development, quality evaluation and storage stability of weaning food. The weaning food was formulated from rice flour, malted green gram flour, flaxseed powder, carrot powder and muskmelon seed powder in different proportions. T1 (70:15:5:5:5), T2 (60:20:5:10:5) and T3 (65:15:5:10:5) and were subjected to sensory evaluation using 9 point hedonic scale.

Nutrient analysis: Analysis were carried out in triplicate formulation, for each sample; three determinations were made. The crude fat was estimated by exhaustive extraction with petroleum ether (B.P 40 TO 0 °C) using a Soxhlet apparatus (AOAC, 2004) [2]. The micro Kjeldahl method was used for determination of protein (N × 6.25). the moisture, ash and crude fibre contents were determined by the AOAC (2004) [2] methods total to carbohydrate was obtained by difference (100-(% moisture + % crude protein + % crude fat + % ash) while food energy was calculated by multiplying the values of crude protein, fat and carbohydrate by factors of 4, 9 and 4 respectively, finding the sum of their products and expressing, the result in kilocalories (Osborne and Voogt, 1978) [24]. all reagents used were of analytical grades.

Physico-chemical analysis

Bulk Density (BD)

The BD (packed and loosed) was determined according to the method described by Okaka and Potter (1977) [22]. 50 Gram sample was put in tinto00ml graduated cylinder. The cylinder was tapped for 40 to 50 times and the bulk density was calculated as weight per unit volume of sample.

BD = wt. of flour /volume of the bulk flour

Water Absorbance Capacity

Water absorbance capacity was determined through the method described by Leach *et al.* (1959) [16] with modifications for small samples. 1 g of the weaning food sample was mixed with 10ml of distilled water in a centrifuge tube and heated at 80 °C for 30 minutes. This was continually sheened 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 water absorbance capacity was calculated as water absorbance capacity= weight of the paste/weight of dry flour.

Results and Discussion

Table 1: Mean acceptability scores of quality attributes of Formulated Weaning Mix

Treatment	Quality Attributes						
	Colour	Appearance	Taste	Texture	Flavour	Consistency	Overall Acceptability
T_1	8.20	8.31	8.18	7.80	7.87	7.83	8.10
T_2	8.02	7.82	7.92	7.76	7.65	7.45	7.82
T_3	7.86	8.07	7.72	7.58	7.41	7.52	7.73

Sensory evaluation: The acceptability of a product is determined by sensory evaluation. Sensory evaluation has been defined as a scientific discipline used to evoke measure, analyse and interpret those responses of senses, perceived by sight, smell, taste and touched to product (Sidel and Stone, 1993) [28]. Sensory analysis can be considered to be an interdisciplinary science that uses human panellists sensory perception related to thresholds of determination of attributes, the variance in individual sensory response to measure the sensory characteristics and the acceptability of food products since there are no one instruments that can replicate or replace the human psychological and emotional response, the sensory evaluation component of any food study is very essential (Lawless and Klein, 1989) [15].

Acceptability trials were calculated by a semi-trained panel consisting of 15 judges from Krishi Vigyan Kendra, Ranchi and were done on nine points Hedonic scale. Table 1 revealed that the formulation T1 exhibited the highest sensory scores for all the sensory attributes in terms of colour (8.20), appearance (8.31), taste (8.18), flavour (7.87), consistency (7.83), and overall acceptability (8.10) followed by T2 and T3.

Table 2: Nutrient composition of single and multiple blend nutraceutical biscuits (per 100 g)

Nutrient (per 100 gm of the sample)	T_1	T_2	T_3
Moisture (g)	6.65±0.11	6.87±0.19	6.71±0.13
Protein (g)	11.21±0.30	11.88±0.33	10.38±0.36
Fat (g)	4.19±0.19	4.33±0.08	4.36±0.11
Crude fibre (g)	1.77±0.15	2.01±0.17	2.12±0.14
Total minerals (g)	3.28±0.10	3.67±0.12	3.52±0.08
Carbohydrate (g)	73.90±1.38	72.38±1.45	73.91±1.53
Energy (kcal.)	378.15±2.98	376.01±2.88	376.67±2.69
Calcium (mg)	52.12±1.49	51.62±1.27	50.68±1.44
Iron (mg)	2.55±0.45	2.65±0.64	2.48±0.50
Phosphorus (mg)	228.60±1.68	236.82±2.11	227.56±1.87
Potassium (mg)	316.11±2.23	312.50±1.71	308.46±1.72

Nutrient Composition: The Nutrient Composition of the formulated weaning mixes was presented in Table 2. The Moisture content of formulated weaning mixes was in the range of 6.65-6.87% and this value is reported to the above value recommended by BIS (4%), however similar value of moisture contents was also reported by Srivastava *et al*. (2001) [30], who had to develop the malted convenience mix based on malted prose millet flour, roasted soybean flour and groundnut flour (70:15:15). Okkfor (2008) [21], also reported moisture contents of 6.43-7.32 present of blended weaning mix comprising of varying proportions of corn bambara nut, sesame and soya bean. The data revealed that preparing weaning food formulation were close to the specifications for weaning foods (Harper and Jansen, 1985). The fat content was in the range of 4.19-4.36 g/100 g. Amaximum limit of 7.5 percent fat was recommended by the Bureau of Indian Standards (BIS, 2006), however, the fat contents of both formulations were within the recommended value (<9.0) of the Prevention of Food Adulteration Rule (PFA, 1991) [25].

The Protein contents of the weaning mix were 10.38-11.31 g/100 g. Wu and Wall (1980) [38] reported that an increase in protein content was attributed to the partial hydrolysis of storage proteins by endogenous proteases produced during malting. The increase in protein content may also be due to processing at high temperatures i.e. Roasting which destroys the anti-nutritional factors which otherwise would have hindered protein absorption (Hulse, 1991) [12]. Malting also increases the liberation of various enzymes that are involved in changing protein, starch and other nutrients into simpler forms (Pulami and Katwal, 2010) [26]. The crude fibre content was in the range of 0.77-1.12 g/100 g which is suitable for complementary foods for young children. The total mineral content was in the range of 3.28-3.67 g/100 g. Onwurafor *et al.* (2013) [23] reported that malting of green gram significantly increases the ash content. Carbohydrate content was in the range of 72.38-73.91 present and energy content ranged from 376.01-378.15 kcal/100 g.

Table 3: Physical properties of developed Weaning Mix

Formulation	Pack BD (g/cm-3)	WAC(ml/g)	SC (%)	Solubility (%)
T_1	0.807	1.46	1.58	0.66
T_2	0.804	1.41	1.52	0.63
T_3	0.805	1.38	1.49	0.60

Physical Prosperities: Physical properties of the complimentary mix are presented in Table 3. The formulation's physical properties range from bulk density 0.804-0.807 g/cm-3, swelling capacity 1.49-1.58% and solubility 060-.66%.

Bulk density has an important functional significance of bulk density is in the preparation of weaning food formulation. Germination has been reported to be a useful method for the preparation of low-bulk weaning foods (Mallshi and Desikachar, 1985) [17]. The water absorbance capacities need to be lowered in order to produce more nutritious and suitable weaning food. This could be achieved by reducing the viscosity of starchy components by malting (Desikachar, 1980) [5]. Aless bulky food contains a higher nutrient content since the volume of food is low. Malting is a well-established, simple, traditional technique for the production of amylase-rich food that can be followed at the household level. During the germination step of malting, a-amylase is transported to the endosperm for mobilization of starch reserves thus the weaning gruels with high a-amylase activity have low viscosity.

Conclusion

An important aspect of complimentary food formulation was studied including physical properties, quantity and quality of nutrients, sensory evaluation, and storage stabilities were also studied. The formulated complimentary food can however be produced by small and large-scale industries and used at the local level to alleviate child malnutrition. The present study provides substantial evidence that malting improves the nutritional and physicochemical characteristics of formulated weaning mix. The mix developed using flaxseed, foxtail millet, malted green gram and banana had improved functional characteristics, high nutritive value with good palatability and storage ability could be useful as nutrient supplementary foods to prevent protein-energy malnutrition as well as other micronutrient deficiency disorder in developing countries.

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