PREPARATION AND EVALUATION OF COMPLENTRAY DIETS FROM GERMINATED WHEAT AND LENTIL FOR BANGLADESHI CHILDERN

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ABSTRCT: During the complementary feeding period, children require a nutrient-dense diet to meet their high nutritional requirements. International interest exists in the promotion of affordable, nutritionally adequate complementary feeding diets based on locally available foods. The objective of this study was to develop a low cost complementary food for children in Bangladesh by using locally available resources. For attaining these five complementary formulations (F_1-F_5) based on germinated wheat flour (GWF), lentil flour (GWF) sugar and milk powder (MP) were appropriately processed and evaluated. The germinated wheat and lentil seed flour were prepared soaking the seed in water for 12hours at 30^{o}C, germinated for 60hours at 33.5^{o}C in a seed germinator, dried at 60^{o}C for 8hours, dehulled, roasted at 100^{o}C for 2 mints, and milled, after this complementary food formulation samples were developed by mixing the ingredients. Samples of the prepared formulations were investigated for proximate composition, functional properties (bulk density, water and oil absorption capacities, swelling power and water soluble index) and sensory evaluation. The proximate composition results indicated that the moisture for complementary food ranged from 5.11-5.22, protein 18.32-27.62, ash 2.67-3.05 crude fiber 1.36-1.81, fat content 1.20-1.28 and carbohydrate 70.73-61.24 were significantly different (p>0.05) from each other. Calculated values for total energy provided by the blends ranged from 375.03-377.39 kcal/100g of dry matter. The overall acceptability score was highest (7.55) in F_3 complementary food followed by F_4 (7.23) ranging from 'like slightly' to 'like moderately". The F_3 complementary food was satisfactorily acceptable. The composition and functional properties of F_3 and F_2 formulations had a good potential for use as complementary foods.

INTRODUCTION

Malnutrition and poor growth during infancy affect a large portion of the world's population; more than 800 million children under 5 years of age suffer from malnutrition and growth failure (Gupta and Sehgal, 1991). Under-nutrition is one of the major problems confronting infants and young children. Malnutrition is particularly prevalent in developing countries, where it affects one out of every three pre-school children (Sarni *et al*., 2009; Happiness *et al*., 2011). Recent findings show that malnutrition is increasing in developing countries, and the major causative factors are infections, unsatisfactory feeding practices, or, more often, a combination of both them (Bhatty and Whitaker, 1987). Recent reports from the World Health Organization show that about 60 percent of all deaths occurring among children under

5 years of age in developing countries can be attributed to malnutrition (Antwi, 2008). It is also estimated that about 50.6 million children under the age of 5 are malnourished, 90 percent of who are from developing countries (Bethesda, 1989).

Complementary foods are any food other than breast milk given to a breastfeeding child. A weaning food is normally a semi-solid food that is used in addition to breast milk and not only to replace it. Weaning foods are mostly prepared in the form of thin porridges or gruels (Brunken *et al*., 2006; Eka *et al*., 2010).When breast milk alone is no longer sufficient, complementary feeding can meet the nutritional requirements of infants. Some other foods and liquids will be needed along with breast milk (Bethesda, 1989).

In most developing countries, complementary diets are derived mainly from local staples such as cereals and tubers, with animal proteins used as supplements. However, since animal proteins are expensive, attempts have been made to identify alternative sources of protein, especially from plants (Ihekoronye and Ngoddy, 1985; Metwalli *et al*., 2011). In countries where cereals are a staple, mothers usually use wheat, rice, maize, or barley in children's homemade foods. The protein of cereals revealed that they are deficient in lysine and tryptophan, but provide adequate amounts of methionine and cysteine which are sulphur-containing amino acids (Ijarotimi and Famurewa, 2006). The amino acid profile of leguminous seeds is considered a rich source of lysine but it is quite deficient in methionine and cysteine (Ikujenlola, 2004). So, combining cereals and leguminous seeds can increase the quality of protein in children's food. (Jood and Singh, 2001).

Provision of low-cost and high-protein foods from local materials for weaning infants is a challenge for developing countries. (Zatolah *et al*., 2010) Low cost weaning foods developed using germination and malting processes. All the formulations were evaluated thrice for their acceptability by a panel of judges using a hedonic scale. Results showed that all the experimental formulations were found to be acceptable obtaining moderately to extremely good scores (Nazni and Sureshkumar, 2011; Compaoré *et al*., 2011). At present, there are no complementary foods manufactured in Bangladesh from locally available food sources. Only a small sector of the community uses imported baby foods. There is, therefore, an urgent need to conduct studies that help in production of low cost nutritional complementary diet based on locally-available materials and evaluate their composition and properties.

MATERIALS AND METHODS

Material: Wheat and lentil seeds were purchased from the local market of Mymensingh, Bangladesh and kept in airtight polyethylene bags at room temperature in a dry place.

Preparation of germinated flou: For preparation of germinated wheat flour (GWF) and germinated lentil flour (GLF), three hundred g of each wheat and lentil seeds were sterilized by soaking in ethanol 2% for 1 min separately. The seeds were then soaked in tap water for 12 h at room temperature. The soaked seeds were germinated in a plastic tray lined with wet paper towels. Two layers of wet paper towels were used to cover the seeds to prevent rapid moisture loss. They were germinated in the seed germinator at $33.5 \pm 2^{o}C$ for 60 h and seeds were watered 2 to 3 times in 24 hours. The sprouts were washed and dried at $60^{o}C$ for 12 h in an electric drier. The dried sprouts were ground in a hammer mill and sieved with a 60 mesh screen. The flour was put, in triplicates, into polyethylene bags and packed in a glass container. They were stored in a refrigerator at $4^{o}C$ until nutritional analysis.

Formulations of complementary food: Complementary foods were formulated by blending of germinated wheat flour; lentil flour; skim milk powder and sucrose in homogenized form. The five formulations were prepared as: F_1(12g GLF + 68g GWF + 10g MP + 10g Sucrose) F_2 (24g GLF + 56g GWF r + 10g MP + 10g Sucrose) F_3 (36g GLF + 44g GWF + 10g MP + 10g Sucrose) F_4 (48g GLF + 32g GWF + 10g MP + 10g Sucrose) F_5 (60g GLF + 20g GWF + 10g MP + 10g Sucrose) The blends were prepared in duplicate and the results of all analysis were reported as the means of three replicates.

Physiochemical analysis: Analysis was carried out on duplicate formulations, for each sample three separate determinations were made in each. The proximate analysis of each formulation was carried out using the standard procedures of AOAC**,** (2004) The Atwater energy factors were used to calculate the caloric (energy) value of each formulation (Osborne and Voogt, 1978) pH was measured by making a 10% (w/v) flour suspension of each sample in distilled water (AOAC**,** 2004). pH recorded with an electronic pH meter. The water and oil absorption capacities were determined by the method of Sosulski *et al.,* (1976). The bulk density (BD) (packed and loosed) was determined according to the method described by Okaka and Potter (1977). The foam capacity (FC) was determined as described by Narayana and Narsinga (1982) with slight modifications. Swelling power was determined through the method described by Leach et al., (1959) with modifications for small samples. Water Solubility was measured according to the method of Anderson (1996).

Sensory evaluation: Sensory evaluation was conducted in Department of Food Technology and Rural Industries (DFTRI) Bangladesh Agricultural University Mymensingh Bangladesh. A total of 10 panelists, ranging in age from 20–40 years and who included students and staff of the DFTRI BAU, Mymensingh Bangladesh participated in this study. Samples were evaluated. The judges evaluated the samples for color and appearance, flavor, odor, texture and overall acceptance on a 9 point scale ranging from "*like extremely"* rated as 9.0 point to "*dislike extremely"* rated as 1.0 point (Larmond,1977) .

Statistical analysis: Results are presented as mean values and standard deviations. Data were subjected to analysis of variance (ANOVA) where applicable and a difference was considered. Values within the same column with different superscript letters are significantly different from each other ($p<0.05$). Means were separated using Duncan's multiple comparison tests.

RESULTS

All the nourishment infants need during the first four to six months comes from either breast milk or infant formula milk. Between four and six months infants should begin taking a wider variety of foods to allow them to grow and develop - this process is called weaning. The five complementary foods were in our study which formulated with different concentration of germinated wheat and lentil. The results are discussed under following headings.

The results of the proximate analysis of the complementary food formulations are presented in Table 1. The moisture content for complementary food formulations ranged 5.11-5.22, ash content ranged 2.67-3.05, crude fiber ranged 1.36-1.81 and carbohydrate ranged 61.24-70.73. The fat content of complementary food formulations were ranged from 1.20-1.29 and proteins values was ranged from 18.32-27.62. Calculated values for total energy provided by the blends ranged from 375.03–377.39 kcal/100 g dry matter. In statistical analysis p>0.05 indicates that the difference was not significant for proximate composition.

Results related to the three functional properties studied are summarized in Table 2. The observed values of pH of formulation (F_1-F_5) were ranged from 5.86-6.16. F_2 complementary food sample has highest pH value (6.16) and F_1 has lowest (5.86) pH value. The result regarding bulk density (lose) of complementary food formulations (F_1-F_5) were ranged 0.54-0.64. F_2 complementary food sample has the highest bulk density value (0.64) and F_4 has lowest value (0.55). For BD (pack) of all formulations ranged between 0.51- 0.62% Germination decreased water absorption capacities but increased oil absorption capacities of all complementary food formulations. The result regarding water and oil absorption capacities presented in Table 2 shows that water absorbance capacity of the five formulations ranged between 1.27–1.49 g/ml and oil absorbance capacity ranged from 1.19–1.53 ml/g.The mean score for. The mean values for swelling capacity are presented in Table 2 which showed that maximum swelling capacity was recorded for F_1 (1.85) and minimum for F_5 (1.64) and others fell in between these values. Germination of seed increased foam capacity and foam volume. The results regarding foam capacity are presented Table 2. Foams prepared from complementary food formulation ranged from (23.64-37.23%). Mean values for water solubility are presented in Table, 2 results showed that maximum water solubility was recorded for F_1 (0.85) and minimum for F_5 (0.59). The statistical analysis for functional properties of complementary food samples were not significantly (p >0.01) different with in formulation.

Table -1: Proximate composition of complementary food formulations prepared from germinated wheat and lentil seed flour

Formulations	Moisture (%)	Ash (%)	Fat (%)	Crud Fiber (%)	Proteins (%)	Carbohydrate (%)	Food Energy K.cal/100g
F_1	$5.22^{a} \pm 0.10$	$2.67^{c} \pm 0.09$	$1.20^{a} \pm 0.10$	$1.81^{a} \pm 0.13$	$18.32^{e} \pm 0.79$	$70.73^{a} \pm 1.84$	$376.27^{a} \pm 0.94$
F_2	$5.16^{a} \pm 0.09$	$2.75^{bc} \pm 0.10$	$1.23^{a} \pm 0.11$	$1.68^{a} \pm 0.14$	$19.22^{d} \pm 0.90$	$69.46^{a} \pm 1.36$	$375.03^{a} \pm 0.81$
F_3	$5.11^{a} \pm 0.11$	$2.82^{b} \pm 0.12$	$1.24^{a} \pm 0.11$	$1.62^{a\,b} \pm 0.08$	$24.97^{c} \pm 0.98$	$64.08^{a} \pm 1.47$	$376.64^{a} \pm 0.86$
F_4	$5.17^{a} \pm 0.08$	$2.91^{ab} \pm 0.10$	$1.29^{a} \pm 0.10$	$1.47^{bc} \pm 0.13$	$25.30^{b} \pm 0.97$	$63.82^{a} \pm 1.31$	$377.39^{a} \pm 0.82$
F_5	$5.14^{a} \pm 0.06$	$3.05^{a} \pm 0.11$	$1.28^{a} \pm 0.09$	$1.36^{c} \pm 0.11$	$27.62^{a} \pm 0.97$	$61.24^{a} \pm 141$	$376.23^{a} \pm 0.71$

Values within the same column with different superscript letters are significantly different from each other (*p< 0.05*)

Table-2: Physical properties of complementary food formulations prepared from germinated wheat and lentil seed flour

Formulations	pH	Pack BD (g/cm^{-3})	Lose BD (g/cm^{-3})	WAC (ml/g)	OAC (ml/g)	SC (%)	FC (%)	Solubility (%)
F_1	$5.86^{a}\pm0.53$	$0.57^{a}\pm0.10$	$0.52^{a}\pm0.10$	$1.48\ ^{a}\pm0.10$	$1.53^{a}\pm0.07$	$1.85^{ab}\pm0.09$	$26.37^{c}\pm0.59$	$0.85^{a}\pm0.07$
F_2	$6.16^{a}\pm0.39$	$0.64^{a}\pm0.12$	$0.62^{a}\pm0.09$	$1.49\ ^{a}\pm0.10$	$1.28^{b}\pm0.11$	$1.77^{bc}\pm0.10$	$23.64^{d}\pm0.77$	$0.74^{a}\pm0.06$
F_3	$6.11^{a}\pm0.43$	$0.62^{a}\pm0.08$	$0.61^{a}\pm0.06$	$1.42^{ab}\pm0.10$	$1.19^{bc}\pm0.06$	$1.82^{a}\pm0.03$	$31.68^{b}\pm0.79$	$0.65^{b}\pm0.04$
F_4	$6.05^{a}\pm0.29$	$0.55^{a}\pm0.07$	$0.51^{a}\pm0.06$	$1.34^{bc}\pm010$	$1.27^{bc}\pm0.07$	$1.75^{cd}\pm0.06$	$36.35^{a}\pm0.69$	$0.62^{b}\pm0.10$
F_5	$6.07^{a}\pm0.38$	$0.58^{a}\pm0.08$	$0.53^{a}\pm0.08$	$1.27\ ^{c}\pm0.10$	$1.21^{c}\pm0.05$	$1.64^{d}\pm0.06$	$37.23^{a}\pm0.60$	$0.59^{b}\pm0.07$

Values within the same column with different superscript letters are significantly different from each other (*p< 0.01*)

Table-3: Sensory evaluation of complementary food formulations prepared from germinated wheat and lentil seed flour

Formulations	Flavour	Mouth Feel	Colour and appearance	Consistency	Overall acceptability
F_1	$6.80^{c} \pm 0.10$	$6.20^{c} \pm 0.10$	$6.72^{c} \pm 0.10$	$6.35^{d} \pm 0.10$	$6.57^{a} \pm 0.10$
F_2	$6.65^{c} \pm 0.10$	$6.30^{c} \pm 0.10$	$6.73^{c} \pm 0.10$	$6.47^{d} \pm 0.10$	$6.66^{b} \pm 0.10$
F_3	$7.42^{a} \pm 0.10$	$7.43^{a} \pm 0.10$	$7.45^{a} \pm 0.10$	$7.48^{a} \pm 0.10$	$7.55^{c} \pm 0.10$
F_4	$6.85^{b} \pm 0.10$	$7.40^{a} \pm 0.10$	$7.38^{b} \pm 0.10$	$7.26^{b} \pm 0.10$	$7.23^{c} \pm 0.10$
F_5	$6.70^{c} \pm0.10$	$6.50^{b} \pm 0.10$	$6.68^{c} \pm 0.10$	$6.64^{c} \pm 0.10$	$6.68^{c} \pm 0.10$

Values within the same column with different superscript letters are significantly different from each other (p< 0.05).

The mean scores of different sensory attributes of the complementary foods are shown in Table 3. The mean score of flavour attribute for F_3 complementary food (7.42) was higher and (6.65) for F_2 weaning foods. The mean score for mouth feel (7.43) was highest in F_3. While the mean scores for colour and appearance for F_3 (7.45) were highest among all weaning formulations. The mean score for consistency was highest (7.48) in the F_3 complementary food. The overall acceptability score exhibited highest (7.55) in F_3 complementary food and lowest F_1 (6.57). The overall acceptability scores of the various sensory attributes are shown in Table 3. Generally the F_3 complementary food was satisfactorily acceptable by sensor panelists. Different superscript letters are significantly different from each other ($p < 0.05$).

DISCUSSION

The quantity of protein required for weaning children is about 20g/day between 6 month and three years (FAO/WHO/UNU, 1985). The results indicated that all the five formulations had adequate protein for complementary feeding purposes. Total energy calculated from the formulations ranged from 375.03–377.39 kcal/100 g on dry matter basis and was similar to specification. These values are similar to the acceptable and typical energy levels of 375 kcal/100 g dry weights provided by industrially processed weaning foods and predicted energy levels (Ayo *et al*., 2011). An important functional significance of bulk density is in the preparation of weaning food formulations. Germination has been reported to be a useful method for the preparation of low bulk weaning foods (Okoye *et al*., 2011). The water absorbance capacities need to be lowered in order to produce a more nutritious and suitable weaning food. This could be achieved by reducing the viscosity of the starchy components by malting (Desikachar, 1980). A less bulky food contains a higher nutrient content since the volume of the food is low. The oil absorbance capacity of germinated weaning food formulations was equally higher than that of un-germinated weaning food formulations (Mahgoub, 1999). The mean score for all formulations ranged between 1.19-1.53 and were not significantly ($p > 0.01$) different from one another. The germination of grains has also been reported to enhance the oil absorbance capacity of the flours produced from it (Giami and Bekebain, 1992). The mechanism of oil absorption may be explained as 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 formation of stable foam is essential in the preparation of several traditional legume-based food products in Nigeria (Mcwatters, 1985). Water solubility index (WSI) decreased with an increase in the germinated flour content of the weaning food formulations. Legumes are the ideal ingredient for the production of such quick foods (Mbofung *et al*., 1999). Sensory evaluation shows that five formulations were slight variations in mouth feel, flavour and overall acceptability and all the formulations were liked by the trained panelists. None of the panelists developed any side effects like diarrhea and emesis after the sensory evaluation The overall acceptability score findings showed that weaning food formulations ranged from '*like slightly*' to '*like moderately*. All the experimental formulations were found to be acceptable obtaining moderately to extremely good score (Usha *et al*., 2010).

Conclusion: The complementary food developed by low-cost food materials locally available in the local market is highly nutritious and can adequately replace the existing low quality traditional counterparts to help enhance the nutritional status of the Bangladeshi children. The nutrient profiles determined for the formulations indicated that the daily requirement of the target nutrients for the weaning infant. Two of the formulations (F_3 and F_2) posses' high level of proteins as well as caloric value and also liked by sensory panelists. From these findings it is concluded that germinated grain flour high nutrient density food formulations were more acceptable.

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