International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2019; 7(4): 1008-1011

Received: 22-05-2019
Accepted: 24-06-2019

Manisha Dutta
Department of Food Science and Nutrition, College of Community Science, Assam Agricultural University, Assam, India

Dr. Pranati Das
Department of Food Science and Nutrition, College of Community Science, Assam Agricultural University, Assam, India

Correspondence
Manisha Dutta
Department of Food Science and Nutrition, College of Community Science, Assam Agricultural University, Assam, India

Formulation and nutritional composition of cereal-pulse based complementary food

Manisha Dutta and Dr. Pranati Das

Abstract
The present study was undertaken with objectives of formulating cereal-pulse based complementary foods made from easily available and staple foods with potential nutritional benefits using household processing techniques to evaluate sensory parameters and study the physico-chemical properties of the developed food. Acceptability trials were conducted. Analysis of variance was done and the means were tested for significance at 5% probability level to find out if there is any significant difference between the treatments. The moisture content ranged from 9.60±0.10 to 13.13±0.06 g/100g, protein from 12.19±0.12 to 13.39±0.09 g/100g, fat content from 7.13±0.01 to 10.82±0.07 g/100g, crude fibre from 0.44±0.07 to 1.09±0.01 mg/100g, total mineral from 1.90±0.04 to 2.16±0.05 g/100g, iron from 9.51±0.34 to 11.24±0.27 mg/100g and calcium from 126.1±0.32 to 131±1.22 mg/100g. The formulated food had good nutritional profile and may also be used for popularizing them among the rural population as a source of nutritious complementary food.

Keywords: Complementary foods, formulation, sensory evaluation, nutrient composition

1. Introduction
Complementary food plays a very important role in the total growth and development of children. Along with mother's milk, infants require nutritionally balanced and calorie-dense supplementary foods to meet the increasing nutritional demands of the growing body (Yaseen *et al*., 2014) [18]. The World Health Organization (WHO) issued a global recommendation from the previous recommendation of breastfeeding of four to six months of age to a full six months to extend the period of exclusive breastfeeding as breast milk has got all the nutrients that babies need to stay healthy and grow. But after six months of age, it may become insufficient to support the nutritional demands of the growing infants and hence, there is the need to complement breast milk with other foodstuffs which can help to improve any deficiency that can result from such inadequacy (Ikujenlola and Adurotoye, 2014) [12]. Processed-cereal based complementary food, commonly called as weaning food or supplementary food means foods based on cereals and/or legumes, nuts and edible oilseeds, processed to low moisture content. It shall contain milled cereal and legumes combined not less than 75 per cent and the product is intended to be mixed with milk or water before consumption. All ingredients, including optional ingredients, shall be clean, safe, suitable and of good quality. The flavour and odour of the processed-cereal based weaning food in the powder form or when reconstituted with water/milk shall be fresh and sweet (BIS, 2006) [6]. A number of convenient fortified proprietary formulas are available in developing countries but they are often too expensive and out of the reach of lower income families. The use of home based complementary food that can be easily prepared, available and affordable, is one feeding alternative that has been recommended to remove the effect of malnutrition on infant and young children (Akinola *et al.,* 2014) [3]. To prepare complementary foods for infants and children the use of high nutrient dense food stuffs like cereal, legumes, fruits, vegetables and animal food products has been suggested by a number of researchers (Akinola *et al.,* 2014; Ikujenlola and Fashakin, 2005; Bala *et al*., 2014) [3, 11, 4]. When legumes are blended with cereals in the right proportions, a mutual complementation of amino acids and consequent improvement in protein quality is achieved (Ghasemzadeh and Ghavidel 2011) [8]. To increase the functionality and nutritional worth, cereals, millets and legumes are usually pre-processed by milling, fermentation, germination, cooking etc. Malting is useful in preparation of low bulk weaning foods as malting activates the enzyme amylase and dextrinifies starch (Ikujenlola, 2008) [10]. Since germination is affordable and more effective, it was incorporated in mixes to contribute to the improvement of nutrition value of

complementary food mixes (Murugkar *et al.*, 2013) [14]. Therefore, the study aims to develop suitable food formulations utilizing germinated cereals, pulses, millets and oil seeds using suitable process for manufacturing them for household use and commercial exploitation with the objectives of formulation of complementary food mixes, evaluation of sensory parameters of the developed food, and nutritional composition of the developed complementary food.

2. Materials and Methods

2.1 Sample selection

Four varieties of rice (*Ranjit, Rangoli Bao*, Red kernel rice and Black rice), foxtail millet, green gram, Bengal gram, sesame seeds and pumpkin seeds were selected for the study. The samples were processed into flour individually, stored in plastic airtight containers and kept in refrigerated temperature.

2.2 Formulation of complementary food

Formulation of complementary foods were done in accordance to the standards of Bureau of Indian Standards (BIS, 2006) [6] which states that complementary foods should contain cereals and legumes combined not less than 75% and the product is intended to be mixed with milk or water before consumption. Seven formulations were developed containing rice flour as the major ingredient from the four different varieties and the proportion of other ingredients were kept same in all the treatments.

2.3 Sensory evaluation of the formulated complementary foods

The sensory evaluation of the formulated mix was done using nine-point Hedonic scale in the sensory evaluation laboratory of Department of Food Science and Nutrition, College of Community Science, Assam Agricultural University. Acceptability trials for sensory charecteristics were conducted by trained and semi-trained panel of fifteen numbers from the Department of Food Science and Nutrition and Department of Food Science and Technology, Assam Agricultural University. Scoring was done on nine-point hedonic scale. All the seven formulations were prepared in the form of porridge made with milk and sugar to find out the acceptability of the products. Porridges were prepared carefully to have the correct consistency and taste and were presented simultaneously at room temperature along with the score cards. The panel members evaluated the samples on the basis of colour, appearance, taste, consistency, flavour and overall acceptability. The scores for each quality were totalled and averaged.

2.4 Nutritional composition of the formulated complementary foods

Moisture, crude protein, crude fat, crude fibre and total mineral content of the samples was determined as per the AOAC. (2010) [2] procedure. The carbohydrate content of the sample was determined by difference method (Gopalan *et al.*, 2000) [9]. Iron and calcium content was determined according to the method described by Ranganna (1986) [15] and A.O.A.C, 2000 respectively. In vitro starch digestibility was assessed with modification of the methods given by Som *et al*. (1992) [16] and Kalia (2002) [13] and *In vitro* protein digestibility was determined according to the method described by Walter *et al*. (1983) [17].

2.5 Statistical analysis

All the data of the experiment were statistically analysed by Analysis of variance (ANOVA) in completely randomized design performed on the data using Statistical Package for Social Sciences (2006) and the means were tested for significance at 5% probability level. Means were separated using Duncan's multiple comparison tests where applicable.

3. Results and Discussions

3.1 Formulation of complementary food mixes

Seven formulations namely T_1, T_2, T_3, T_4, T_5, T_6 and T_7 were developed containing rice flour as a major ingredient from different varieties of rice - *Ranjit, Rangoli Bao, Kolamai Gutiya Hali* (Red kernel rice) and black rice. Other ingredients were foxtail millet, Bengal gram and green gram, sesame and pumpkin seed flour in different proportions. The composition of the formulated complementary food mixes are given in Table 1.

Table 1: Formulation of the complementary food mixes

Treatments	Ingredients (g)								
	R_1	R_2	R_3	R_4	FM	BG	GG	SS	PS
T_1	50	-	-	-	20	10	10	5	5
T_2	-	50	-	-	20	10	10	5	5
T_3	-	-	50	-	20	10	10	5	5
T_4	-	-	-	50	20	10	10	5	5
T_5	25	25	-	-	20	10	10	5	5
T_6	25	-	25	-	20	10	10	5	5
T_7	25	-	-	25	20	10	10	5	5

(R_1=*Ranjit*, R_2=*Rangoli Bao*, R_3= *Kolamai Gutiya Hali* (Red Kernel Rice), R_4=Black Rice, FM=Foxtail Millet, BG=Bengal Gram, GG=Green Gram, SS=Sesame Seeds, PS=Pumpkin Seeds)

3.2 Sensory evaluation of the formulated complementary food mixes

The sensory parameters in each formulation scored significantly different scores at ($p \leq 0.05$) and are given in Table 2. T_1 scored highest (8.13±0.16) and T_4 scored lowest (6.93±0.24) in colour; T_7 scored highest (8.13±0.19) and T_1 scored lowest (7.26±0.11) in flavour; T_4 scored highest (8.13±0.09) and T_7 scored lowest (7.33±0.23) in consistency; T_5 scored highest (8.13±0.16) and T_7 scored lowest (7.2±0.22) in appearance; T_5 scored highest (8.2±0.17) and T_4 scored lowest (7.2±0.26) in taste; T_1 scored highest (8.53±0.13) and T_2 scored lowest(7.53±0.19) in overall acceptability. Better taste and better acceptability of germinated and malted food mixes may be due to increase in the simple sugar content in the malted samples which adds a pleasant sweet flavour to food products (Bellaio, 2013) [5].

Table 2: Sensory evaluation of the formulated complementary food mixes

Sensory attributes	T_1	T_2	T_3	T_4	T_5	T_6	T_7	CD 0.05
Colour	8.13 ± 0.16^{a}	8.13 ± 0.23^{a}	7.93 ± 0.22^{ab}	6.93 ± 0.24^{c}	8.06 ± 0.18^{a}	7.93 ± 0.15^{ab}	7.06 ± 0.26^{bc}	0.49
Flavour	7.26 ± 0.11^{b}	$7.53\pm0.13^{a,b}$	$7.93\pm0.20^{a,b}$	8.06 ± 0.20^{a}	$7.6\pm0.13^{a,b}$	$7.86\pm0.19^{a,b}$	8.13 ± 0.19^{a}	0.40
Consistency	$7.93\pm0.18^{a,b}$	$7.46\pm0.16^{a,b}$	$7.86\pm0.16^{a,b}$	8.13 ± 0.09^{a}	$8.0\pm0.13^{a,b}$	$7.8\pm0.14^{a,b}$	7.33 ± 0.23^{b}	0.38
Appearance	$7.93\pm0.18^{a,b}$	$7.73\pm0.20^{a,b}$	$7.73\pm0.24^{a,b}$	7.2 ± 0.26^{b}	8.13 ± 0.16^{a}	$8.0\pm0.16^{a,b}$	7.2 ± 0.22^{b}	0.50
Taste	$8.06\pm0.18^{a,b}$	$8.0\pm0.16^{a,b}$	$7.66\pm0.18^{a,b}$	7.2 ± 0.26^{b}	8.2 ± 0.17^{a}	$7.8\pm0.24^{a,b}$	$7.4\pm0.19^{a,b}$	0.47
Overall Acceptability	8.53 ± 0.13^{a}	7.53 ± 0.19^{c}	$8.4\pm0.19^{a,b}$	$8.2\pm0.14^{a,b,c}$	7.6 ± 0.21^{c}	$7.66\pm0.18^{b,c}$	7.6 ± 0.16^{c}	0.41

Values are mean ± SD of 15 replications

Means with different superscript within the same row are significantly different at $p\leq0.05$

3.3 Nutrient composition of the formulated complementary food mixes

The nutrient composition in terms of moisture, crude protein, crude fat, crude fibre, total mineral, carbohydrate, iron, calcium, *in vitro* starch digestibility and *in vitro* protein digestibility of the formulated complementary food mixes are presented in Table 3.

The moisture content of these formulated complementary food mixes were above the value recommended by Bureau of Indian Standards, 2006 (4%) and Codex International Standard, 1994 (10%). The difference in the moisture content between the formulations may be due to differences in the moisture content of the rice varieties used for the preparation of the food mixes. Gopalan *et al*., (2000) [9] stated that the higher moisture content of formulated weaning mixes could be due to use of ingredients like sesame and rice flour. Another contributing factor could be due to high humidity and climatic variation existing in the study region. While comparing the protein content of these formulations with Bureau of Indian Standards (2006) [6] it was observed that the protein content of the formulations of the present study was lower but it satisfies the protein content recommendation of Prevention of Food Adulteration Rule (1991) which ranges from 10.0 to 16.0 %, thereby making the present formulations suitable as a nutritious complementary food. The difference in the protein content between the formulations may be due to differences in the protein content of the rice varieties used for the preparation of the food mixes. The difference in fat content between the formulations could be due to differences in the fat content of the rice varieties used for preparation of the food mixes. The fat content of these formulated food mixes were within the recommended value (<9.0) of Prevention of Food Adulteration Rule (PFA, 1991). The crude fibre content of these formulated complementary food mixes were within the value recommended by Bureau of Indian Standards, 2006 (1%). The difference in crude fibre content between the formulations could be due to differences in the fibre content of the rice varieties used for preparation of the food mixes. The difference in total mineral content between the formulations could be due to differences in the mineral content of the rice varieties used for preparation of the food mixes. According to recommendations of Bureau of Indian Standard (2006) [6], the total mineral content of cereal based weaning food should be 5.0 percent. The difference in carbohydrate content between the formulations could be due to differences in the carbohydrate content of the rice varieties used for preparation of the food mixes. According to BIS (2006) [6], the carbohydrate content should be 55 g/100g. The codex specified a minimum standard level of 58% carbohydrates. The difference in iron content between the formulations could be due to differences in the iron content of the rice varieties used for preparation of the food mixes. Bureau of Indian Standards (2006) [6] recommendations of iron content of weaning foods should be 5.0mg/100g. The difference in calcium content between the formulations could be due to differences in the calcium content of the rice varieties used for preparation of the food mixes. The recommended calcium content of complementary foods according to Bureau of Indian Standards (2006) [6] is 1g/100g and Prevention of Food Adulteration Rule (1991) is 230mg/100g respectively. The required daily allowance (RDA) for calcium content in the complimentary foods is 400-425 mg (CODEX 1991). The calcium content of the mixes may be increased if it is cooked in milk. The difference in protein digestibility between the formulations could be due to differences in the rice varieties used for preparation of the food mixes. According to Codex standard (1991) [7], protein digestibility content in a weaning mix should not be less than 70% per 100g mix. The results of protein digestibility of the present study were in accordance with the codex standard. The difference in starch digestibility between the formulations could be due to differences in the rice varieties used for preparation of the food mixes.

Table 3: Nutrient composition of the formulated complementary food mixes:

	T_1	T_2	T_3	T_4	T_5	T_6	T_7	$CD_{0.05}$
Moisture (g/100g)	10.73 ± 0.03^{c}	10.16 ± 0.03^{d}	13.13 ± 0.06^{a}	$10.93\pm0.06^{b,c}$	09.60 ± 0.10^{e}	11.13 ± 0.03^{b}	10.36 ± 0.12^{d}	0.17
Crude protein(g/100g)	12.19 ± 0.12^{c}	$12.53\pm0.14^{b,c}$	$12.66\pm0.03^{b,c}$	13.39 ± 0.09^{a}	$12.36\pm0.13^{b,c}$	$12.42\pm0.07^{b,c}$	12.79 ± 0.11^{b}	0.28
Fat(g/100g)	7.13 ± 0.01^{e}	8.20 ± 0.13^{c}	8.82 ± 0.07^{a}	8.80 ± 0.13^{a}	8.11 ± 0.08^{d}	8.32 ± 0.36^{b}	8.35 ± 0.24^{b}	0.46
Fibre(g/100g)	$0.80\pm0.06^{a,b,c}$	$0.99\pm0.05^{a,b}$	$0.68\pm0.01^{c,d}$	$0.50\pm0.06^{c,d}$	0.44 ± 0.07^{d}	1.09 ± 0.01^{a}	$0.75\pm0.01^{b,c}$	0.15
Total mineral(g/100g)	1.90 ± 0.04^{b}	2.16 ± 0.05^{a}	$2.06\pm0.04^{a,b}$	$2.01\pm0.02^{a,b}$	$2.05\pm0.03^{a,b}$	$2.0\pm0.04^{a,b}$	$1.96\pm0.06^{a,b}$	0.11
Carbohydrate(g/100g)	77.63 ± 0.02^{a}	73.5 ± 0.11^{e}	76.75 ± 0.09^{b}	75.30 ± 0.07^{d}	76.04 ± 0.10^{c}	$76.22\pm0.06^{b,c}$	76.15 ± 0.08^{c}	0.28
Iron(mg/100g)	11.24 ± 0.27^{a}	9.56 ± 0.40^{b}	$9.54\pm0.34^{a,b}$	$10.30\pm0.38^{a,b}$	9.51 ± 0.34^{b}	$10.21\pm0.15^{a,b}$	$9.95\pm0.05^{a,b}$	0.75
Calcium(mg/100g)	$127.3\pm0.81^{a,b}$	$126.1\pm0.32^{a,b}$	$130.3\pm0.40^{a,b}$	131.0 ± 1.22^{a}	125.6 ± 0.89^{b}	$129.7\pm0.73^{a,b}$	$129.8\pm0.32^{a,b}$	2.44
Protein digestibility (%)	70.21 ± 0.01^{d}	70.56 ± 0.06^{d}	71.5 ± 0.1^{c}	73.4 ± 0.2^{a}	70.5 ± 0.02^{d}	70.7 ± 0.07^{d}	72.2 ± 0.12^{b}	0.28
Starch digestibility (mg maltose/g of sample)	124.62 ± 0.32^{c}	125.27 ± 0.17^{c}	128.47 ± 0.12^{a}	$127.41\pm0.19^{a,b}$	124.8 ± 0.4^{c}	$126.0\pm0.5^{b,c}$	125.25 ± 0.15^{c}	0.79

4. Conclusion

It is evident from the present study that the formulated complementary food mixes made from easily available and affordable food staples using household processing techniques had a good nutritional profile and physico-chemical properties which were comparable with the standards of Bureau of Indian Standards (2006) [6], Prevention of Food Adulteration (1991) and CODEX (1991) except moisture, total mineral and calcium content. The formulated complementary food mixes are nutritious and have high acceptability scores on sensory attributes. Therefore, the formulations may be used for popularizing among the rural and urban populations as a source of nutritious complementary food.

Fig 1: Sensory evaluation of the formulations

Fig 2: All the seven complementary mixes (Final product)

5. References

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