Research Article

Functional Properties and Storage Qualities of Developed Complementary Food

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Abstract

The present study was undertaken with an aim of formulating complementary foods made from staple foods with the objective of studying the functional properties and storage qualities of the developed food. The studied was carried out in Assam Agricultural University for one year. Seven formulations were prepared and were analysed for functional properties in terms of bulk density, water holding capacity and viscosity along with storage stability in terms of free fatty acid, peroxide content and sensory evaluation. Analysis of variance was done using Statistical Package for Social Sciences. Functional properties and storage qualities revealed that they differ significantly across 60 days of storage period. Sensory evaluation scores of the formulated complementary foods showed that they had good acceptability scores across the storage period These food mixes may be used for popularizing the formulations among the rural population as a source of nutritious complementary foods and may provide possible opportunities for entrepreneurship development.

Keywords: Bulk density, Complementary foods, Formulation, Functional properties, Storage qualities, Viscosity, Water holding capacity

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Introduction

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 material shall be manufactured and packed under hygienic conditions. 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 [1]. The product shall be packed in containers which will safeguard the hygienic and other qualities of the food and the containers, including packaging materials, shall be made only of substances which are safe and suitable for their intended uses [2]. Nutrient fortified cereals are the first complementary foods introduced to the infant, followed by fruits and vegetables in most developed societies. 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 [3]. Complementary foods that are produced only from cereals are deficient in certain essential amino acids (lysine and tryptophan) which are essential for the adequate growth of infant. The essential amino acids are present in reasonable quantities in legumes [4]. Therefore, when legumes are blended with cereals in the right proportions, a mutual complementation of amino acids and consequent improvement in protein quality is achieved [5]. Therefore, the present research study aims to develop suitable food formulations utilizing germinated cereals, pulses, millets and oil seeds and manufacturing them at household level and also for commercial exploitation.

Methodology

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.

Formulation of the complementary food

Formulation of complementary foods were done in accordance to the standards of Bureau of Indian Standards [1] 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.

Functional properties of the complementary food

Bulk density was determined using the method suggested by Lewis [6]. Viscosity of the sample was determined as per modification method given by Hallic and Kelly [7] by using Brookfield viscometer. The Water Holding Capacity of the sample was determined using the method of Onwuka [8].

Storage studies of the formulated complementary food mixes

Peroxide value of the sample was determined by the AOAC [9] method. Free fatty acid content of the samples was determined following the AOAC [10] method. Sensory attributes for the developed formulations were analysed across storage up to 60 days in airtight plastic containers (PET) stored at refrigerated temperature by a panel of 15 judges selected at random from the Department of Food Science and Nutrition and Department of Food Science and Technology, Assam Agricultural University using a score card of nine point Hedonic Rating Scale.

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.

Results

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. Composition of the formulated complementary food mixes are given in **Table 1**.

Table1. 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)

Functional properties of the complementary food

The bulk density and water holding capacity of the formulated complementary food mixes are presented in **Table 2**. The difference in the bulk densities between the formulations could be due to differences in the rice varieties used for preparation of the food mixes. Studies reported by Ikujenlola and Adurotoye [11] on complementary foods made from mixtures of malted and unmalted Quality Protein Maize and cowpea showed bulk density 0.65 to 0.68 g/ml in malted samples and 0.70 to 0.73 g/ml in unmalted samples. Malting reduces the amount of water available for gelatinization and therefore it is a desirable characteristic for making thinner gruels [12]. The probable reason for the significant variation in water holding capacity among the formulations could be due to difference in the carbohydrate contents of the formulations. Lower carbohydrate content decreases the water absorption capacity for most food systems [13].

Table 2: Bulk density and Water holding capacity of the formulated complementary food:

	T_1	T_2	T_3	T_4	T_5	T_6	T_7	CD 0.05
Bulk density (g/ml)	0.60 ± 0.00^{g}	0.65 ± 0.00^{c}	0.66 ± 0.00^{b}	0.69 ± 0.00^{a}	0.62 ± 0.00^{f}	0.63 ± 0.00^{e}	0.64 ± 0.00^{d}	0.00
Water holding capacity (ml/100g)	237.0 ± 2.0^{a}	233.0 ± 3.0^{ab}	227.0 ± 2.0^{ab}	223.0 ± 3.0^{b}	$234.5\pm0.5^{a,b}$	$232.0\pm1.0^{a,b}$	$227.0\pm3.0^{a,b}$	6.09

Values are mean ± SD of 3 replications
Means with different superscript within the same row are significantly different at $p\leq0.05$

The cold paste viscosities of formulated complementary food mixes prepared from 10, 20 and 30 per cent slurry concentrations are represented in **Table 3**. The viscosities of the formulations from 10% slurry concentration with spindle-2 ranged from 152.0±2.0 to 167.2±.02 mPa.s. The viscosities of the formulations from 20% slurry concentration with spindle-4 ranged from 1495.0±5.0 to 1602.5±2.5 mPa.s. The viscosities of the formulations from 30% slurry concentration with spindle-4 ranged from 3585.0±5.0 to 3687.5±2.5 mPa.s. The viscosity of the cooked paste of formulated weaning mixes increased significantly ($p<0.05$) with slurry concentration. Studies reported by Faki (2004) in a study of sorghum based weaning food found that the viscosity of blends containing amylase rich foods were significantly lower ($p<0.05$) than that of other blends at all comparable slurry concentration. Ikujenlola and Fashakin stated that reduction of viscosity in diets prepared from amylase rich flours is due to starch saccharification or dextrinization caused by the activities of amylases that developed during germination [12].

Table 3: Viscosity of the formulated complementary food mixes at different slurry concentration:

	Slurry concentration	Spindle	T_1	T_2	T_3	T_4	T_5	T_6	T_7	CD 0.05
Viscosity (mPa.s)	**10%**	2	$165.5\pm0.5^{a,b}$	167.2 ± 0.2^{a}	$154.2\pm1.2^{c,d}$	152.0 ± 2.0^{d}	166.5 ± 1.5^{a}	$159.2\pm1.2^{b,c}$	$161.0\pm1.0^{a,b,c}$	3.29
	20%	4	1602.5 ± 2.5^{a}	1582.5 ± 2.5^{b}	1547.5 ± 2.5^{c}	1495.0 ± 5.0^{d}	$1587.5\pm2.5^{a,b}$	1577.7 ± 2.2^{b}	1547.5 ± 2.5^{c}	7.92
	30%	4	$3672.5\pm2.5^{a,b}$	3687.5 ± 2.5^{a}	3652.5 ± 2.5^{c}	3585.0 ± 5.0^{d}	3677.5 ± 2.5^{a}	$3661.0\pm1.0^{b,c}$	$3657.5\pm2.5^{b,c}$	7.66

Values are mean ± SD of 3 replications
Means with different superscript within the same row are significantly different at $p\leq0.05$

Storage studies of the formulated complementary food mixes

The shelf life of the formulated complementary food mixes were studied by the content of free fatty acid and peroxide over storage for a period of 0, 30 and 60 days. The mean free fatty acid and peroxide values of the formulations across storage periods are presented in **Table 4**. Analysis of variance (ANOVA) showed that there was a significant increase ($p\leq0.05$) in the mean free fatty acid values and peroxide content across storage. The difference in the free fatty acid content between the formulations may be due to differences in the rice varieties used for the preparation of the food mixes. The increase may be due to the higher moisture content, effect of temperature and presence of bran in the rice samples. Increase in total amount of free fatty acid during storage might be attributed to the activities of lipases and lipolytic acyl-hydrolases [14]. The findings of the peroxide values in the study were within the standard specified by Prevention of Food Adulteration Rule, 1991 (10 m moles/kg fat). Therefore, the formulated mixes could be considered acceptable in all the storage period. The difference in the peroxide content between the formulations may be due to differences in the rice varieties used for the preparation of the food mixes. The increase in peroxide values during storage is probably due to peroxidation of double bonds in unsaturated fatty acids which respectively breakdown in order to produce secondary oxidation products that may indicate rancidity [15].

Table4. Free fatty acid and peroxide values of formulated complementary mixes across storage:

Parameters	Period of evaluation (Days)	T_1	T_2	T_3	T_4	T_5	T_6	T_7	CD 0.05
Free fatty acid (%)	0	3.24±0.62^{g}	3.78±0.68^{d}	3.32±0.22^{f}	3.38±0.02^{e}	3.90±0.44^{c}	5.50±0.30^{a}	5.34±0.31^{b}	1.70
	30	5.15±0.70^{g}	5.85±0.28^{d}	6.83±0.14^{b}	5.43±0.42^{f}	5.71±0.14^{e}	7.25±0.28^{a}	6.69±0.56^{c}	1.73
	60	7.53±0.28^{d}	7.25±0.28^{e}	7.81±0.28^{c}	8.09±0.0^{b}	6.97±0.28^{f}	8.23±0.14^{a}	7.53±0.28^{d}	0.00
Peroxide (m moles/kg fat)	0	6.0±0.2^{c}	5.5±0.10^{f}	5.55±0.35^{e}	5.65±0.55^{d}	6.5±0.1^{a}	6.05±0.25^{b}	6.05±0.65^{b}	0.00
	30	7.9±0.02^{c}	7.6±0.2^{e}	7.6±0.2^{e}	7.75±0.45^{d}	8.4±0.2^{a}	8.1±0.3^{b}	7.75±1.05^{d}	1.41
	60	9.95±0.15^{b}	9.55±0.15^{e}	9.85±0.75^{c}	9.05±0.25^{f}	10.35±0.05^{a}	10.35±0.15^{a}	9.75±0.95^{d}	0.00

Values are mean ± SD of 3 replications
Means with different superscript within the same row are significantly different at $p \leq 0.05$

Figure1. Sensory evaluation in the laboratory of Dept. of Food Science and Nutrition, AAU

Figure1. All the seven formulated complementary food mixes

Sensory evaluation of the formulated complementary food mixes across storage

Sensory evaluations of the present formulations across storage are presented in **Table 5**. Data revealed that the mean scores of sensory attributes of the formulations stored in plastic airtight containers (PET) at refrigerated temperature did not change significantly. However, there was a slight decrease in the scores of the sensory attributes across storage of 60 days. At 60 days, T_1 scored highest in colour and overall acceptability, T_7 scored highest in flavour, T_4scored highest in consistency and T_5 scored highest in appearance and taste. Sensory evaluation scores of the formulated complementary foods showed that they had good acceptability scores till the end of the storage period.

Table5. Sensory evaluation of the formulated complementary food mixes across storage

Storage period (Days)	Quality attributes					
	Colour	Flavour	Consistency	Appearance	Taste	Overall acceptability
			T_1			
0	8.13±0.16	7.26±0.11	7.93±0.18	7.93±0.18	8.06±0.18	8.53±0.13
60	8.20±0.14	7.20±0.22	7.86±0.16	7.86±0.16	7.93±0.18	8.40±0.19
			T_2			
0	8.13±0.23	7.53±0.13	7.46±0.16	7.73±0.24	7.66±0.18	7.53±0.19
60	8.06±0.20	7.40±0.19	7.40±0.16	7.73±0.24	7.53±0.13	8.36±0.20
			T_3			
0	7.93±0.22	7.93±0.20	7.86±0.16	7.73±0.24	7.66±0.18	8.40±0.19
60	7.86±0.16	7.73±0.24	7.73±0.24	7.53±0.13	7.53±0.13	8.28±0.14
			T_4			
0	6.93±0.24	8.06±0.20	8.13±0.09	7.20±0.26	7.20±0.26	8.20±0.14
60	6.93±0.24	8.00±0.13	8.06±0.18	7.06±0.26	7.16±0.26	8.13±0.16
			T_5			
0	8.06±0.18	7.60±0.13	8.00±0.13	8.13±0.16	8.20±0.17	7.60±0.21
60	8.00±0.16	7.53±0.13	7.93±0.22	8.00±0.16	8.13±0.16	7.53±0.13
			T_6			
0	7.93±0.15	7.86±0.19	7.80±00.14	8.00±0.16	7.80±0.24	7.40±0.19
60	7.86±0.16	7.73±0.24	7.73±0.0024	7.93±0.22	7.73±0.24	7.33±0.23
			T_7			
0	7.06±0.26	8.13±0.19	7.33±0.23	7.20±0.22	7.40±0.19	7.60±0.16
60	7.06±0.26	8.06±0.20	7.30±0.23	7.06±0.26	7.33±0.23	7.53±0.13

Results are mean values ± SD of 10 replications

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 desirable functional properties and also showed good results in respect of keeping quality and sensory characteristics. Therefore, the formulations may be used for popularizing among the rural and urban populations as a source of nutritious complementary food and it will provide possible opportunity to any entrepreneuring organisations to adopt the technology of developing these complementary foods.

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