J. Biol. Today's World. 2017 Sep; 6 (9): 164-173

Journal of Biology and Today's World
Journal home page: http://journals.lexispublisher.com/jbtw

Received: 15 May 2017 • Accepted: 28 July 2017

Research

doi:10.15412/J.JBTW.01060902

Functional Properties, Physical Parameters and Sensory Attributes in Extruded Products Based on Cereals, Pulseses and Legumes

Mohammad Reza Shadan[1], Fahimeh Khoushabi[2], Javad Sharifi-Rad[3*]

[1] Department of Nutrition, Research Center for Clinical Immunology, Ali Ebne Abi Taleb Hospital, Zahedan University of Medical Sciences, Zahedan, Iran

[2] Department of Nutrition, School of Health, Zabol University of Medical Sciences, Zabol, Iran

[3] Phytochemistry Research Center, Shahid Beheshti University of Medical Sciences, Tehran, Iran

*Correspondence should be addressed to Javad Sharifi-Rad, Phytochemistry Research Center, Shahid Beheshti University of Medical Sciences, Tehran, Iran; Tel: +9888200104; Fax: +9888200124; Email: javad.sharifirad@gmail.com.

ABSTRACT

The typical diet in populations with a high prevalence of malnutrition is consists predominantly of a starch-rich staple, such as a cereal or tuber, limited amounts of fruits, vegetables, legumes, pulses, and little or no animal-source foods. The aim of this study was determine the functional properties and sensory evaluation of extruded products based on cereals, pulses and legumes. Twelve composite flours were prepared using cereals, pulses and legumes; then were formulated and extruded by a twin screw extruder. The extruded samples were analyzed for their densities such as tap, true and bulk densities; also they were analyzed for their extrudate diameter, expansion ratio, expansion area and finally hardness. Samples were evaluated for their water absorption index, water solubility index and water holding capacity. Then the panels of semi-trained judges consisting of 100 members were given the twelve extruded products for assessment their organoleptic characteristics including appearance, color, taste, texture, and overall acceptability based on consumer acceptability studies. Analysis of data indicated that the extruded product of 12 samples had best functional properties compared to others; in addition, found data demonstrated that this combination was significantly better in color, flavor, texture and overall acceptability than others. It is considerable that mixing of cereals, pulses and legumes along with extrusion method will improve the quality of final products.

Key words: Extruded Products, Functional properties, Sensory evaluation, Cereals, Pulses.

1. INTRODUCTION

Today food security remains an unfulfilled dream for more people who are unable to lead healthy and active lives because they lack access to safe nutritious food. More than 840 million people have not access to enough food as their daily basic needs, while more than one third of the world's children are stunted due to diets inadequate in quantity (1). Inadequate nutrition in high risk groups such as infants, children, elderly, pregnant and lactating mothers, who often have high nutrient needs, may lead to malnutrition, growth retardation, reduced work capacity and poor mental and social development (2). Analysing the data of the maternal and child malnutrition study group (MCUSG) from 388 national surveys in 139 countries has provided a new estimation of the global prevalence of underweight, stunting, and wasting among children below 5 years of age, based on the new world health organization (WHO) child growth standards (3, 4). There are 556 million children under 5 years of age in low-income countries that 20% (112 million) of them are underweight, 32% (178 million) are stunted, and 10% (55 million) were wasted; 3.5% (19 million) are severely wasted. Thus, about 36 million children are suffering from moderate wasting. Underweight, stunting, and wasting are considered as some factors for the child mortality and disease burden. Annually, about 10 million deaths are occurred in children below 5 years of age; it was estimated that the attributable fractions of underweight, stunting, and wasting were 19%, 15%, and 15%, respectively (3, 4).

Malnutrition also prevents people from reaching their full intellectual and productive potential. In children, severe malnutrition is led to 1 million deaths annually (5). Behind this, there are about 20 million children under the age of five that suffering from severe malnutrition. In 2010, 7.6 million children across the world died before reaching their fifth birthday, while in 2011 about 165 million children under the age of five were stunted (low height for age) and 101 million were underweight. Malnutrition causes children to be more susceptible to illness, and results in long-term effects on children's development and health. Providing adequate nutrition during infancy early childhood is a paramount important factor for fostering all around physical, mental and emotional development to optimum levels (5). Inadequate nutrition may lead to malnutrition, growth retardation, reduced work capacity and poor mental and social development. Malnutrition exists in some form in almost every country that is affected many children and adults. A study conducted in urban and rural areas of Iran by Sayari et al (6) reported that 15.4% of the children showed moderate to severe nutritional stunting. A survey conducted in Iran in the year 1995 by Ghassemi et al (7) reported that estimated rates of stunting, underweight and wasting were 18.9%, 18.7% and 6.6%, respectively. Malekzadeh et al (8) studied the prevalence of malnutrition in 544 rural school children from Boirahmad rural area in central of Iran. They reported that based on 2SD cut off point for Indices, 15.7% (C1= 12.6-18.8), 12.5% (C1=9.9-15.5) and 3.6% (C1=2-5.2) of children were suffered from stunting, underweight and wasting. Sharifzadeh et al (9) studied the prevalence of malnutrition in 1807 under 6 years old Iranian children from urban area of southern Khorasan of Iran and reported that weight index was normal in 52.5% of them and 34.4% was slightly underweight, 11.7% was moderate underweight and 1.2% was severely underweight. Payandeh et al (10) conducted a study on prevalence of malnutrition in children under 5 years in northeast of Iran and their results showed that the rate of underweight, stunting and wasting was 7.5%, 12.5% and 4.4%, respectively. Protein-energy malnutrition among children is the major health challenges in developing countries (11, 12) and is ascribed to the inappropriate complementary feeding practices, low nutritional quality of traditional complementary foods and high cost of quality protein-based supplementary foods (13-19). The tragic consequences of malnutrition are including death, disability, stunted mental and physical growth; these are resulting in low national socioeconomic development. The high prevalence of deaths each year among children aged under five years in the developing countries are mainly associated with malnutrition (12). The interaction of poverty, poor health and poor supplementary feeding practices has a multiplier effect and also contributes significantly towards growth retardation, poor cognitive development, illness and death in children in developing countries (20, 21). It is well known that high cost of fortified nutritious proprietary supplementary foods in many developing countries are always one of challenge in most families (22) while many families depend on inadequately processed and low quality traditional supplementary foods to wean their children. Supplementary foods may be either prepared specially for the young child, both to meet age-related nutritional needs and to mitigate immaturity in chewing and swallowing, or they may be selected from the same foods consumed in a family (12). The typical diet in populations with a high prevalence of malnutrition consists predominantly of a starch-rich staple, such as a cereal (Maize, Rice) or tuber (Cassava), with limited amounts of fruits, vegetables, legumes, pulses, and little or no animal-source food. This diet is bulky and has a low density of energy and nutrients, low bioavailability of minerals that will lead to impaired growth, reduced development, and low host defence against infections and disease. Young children are also likely to be more sensitive to the effect of anti-nutrients, e.g., high levels of phytate, which impairs the absorption of several growth-limiting minerals, such as zinc. Infants and young children are especially vulnerable against malnutrition because they have a high growth velocity and also have high energy consumption and nutrient needs. Growth velocity up to the age of about 2 years is especially high, and during this period the brain reaches almost 90% of adult size. Findings on nutritional status have also shown that malnutrition among children below 5 years of age develops mainly during 6 to 18 months (4, 23). In current research, different methods of processing such as soaking, germination, milling, and finally extrusion were used to increase the availability of nutrients and improvement palatability of new products. Extrusion cooking is an ideal method for manufacturing a number of food products from snacks and breakfast cereals as baby foods and extrusion also permits the utilization and co-processing of various by-products. However researchers selected this method along with other methods of processing such as soaking, germination, and milling to formulate and produced a formula with best and optimized conditions. Extruded foods have been proven in order to provide nutritious products and are combined with the quality ingredients of produce processed foods that contain precise levels of each required nutrient (24). The aim of present study was to identify supplementary foods for children based on locally available consumed cereals and legumes in Iran to increase their nutritional qualities of food ingredients and providing them with low content of anti-nutrients, low risk of contamination, acceptable taste and texture, easy preparing, affordable and available.

2. MATERIAL AND METHODS

2.1. Extrusion cooking

A co-rotating twin-screw extruder (Basic Technology Pvt. Ltd., Kolkata, India) with three zones (feeding zone, cooking zone, and die zone) was used to process the different formulation. The length-to diameter (L/D) ratio of the extruder was 8:1. The main drive of extruder was provided with a 7.5 HP motor (400 V, 3 HP motor, 50 cycles). The output shaft of worm reduction gear was provided with a torque limiter coupling. The barrel of the extruder received the feed from a co-rotating variable speed feeder. The barrel was provided with two electric band heaters and two water cooling jackets. A temperature sensor was fitted on the front die plate, which was connected to a temperature control unit. The selected die diameter was 1.8 mm. Overall extruder was optimized at extrusion parameters namely temperature: 115 ºC and 90 °C for two different heating zones, die diameter: 1.8 mm and screw speed: 400 rpm. The product was collected at the die end and it kept at 60 ± 0.5 °C in a tray dryer to remove the extra moisture from the product. Then samples were packed in polyethylene covers and were stored during 3 months at room temperature.

2.2. Standardization of products

All products were standardized in the lab of food technology department. Composite of products was prepared by mixing corn flour, rice flour, germinated or un- germinated and dehulled or whole cowpea flour, Chickpea flour, red gram flour and Green gram in the different ratios on a dry-to-dry weight basis; the details are shown in the Table 1. These blends were chosen according to preliminary tests for acceptability products physico-chemical, nutritional and functional characteristics in the final product. The blended samples were conditioned to 21–22% moisture by spraying a calculated amount of water and mixing at medium speed in a blender continuously. The feed material was then allowed to stay for 3 hours to equilibrate at room temperature prior to extrusion. This preconditioning procedure was employed to ensure uniform mixing and hydration and to minimize the variability in the state of feed material. All the formulas were extruded in triplicates.

Table 1. Proportion of extruded products based on cereals, pulses and legumes (Corn, Rice, Chickpea, Cowpea and Green gram)

S. No.	Ingredient of formulation	Proportion
1	Corn	100
2	Corn: Rice	75:25
3	Corn: Cowpea (UG**and without skin)	75:25
4	Corn: Cowpea (G*and with skin)	75:25
5	Corn: Cowpea (UG**and with skin)	75:25
6	Corn: Cowpea (G*and with skin)	65:35
7	Corn : Cowpea (UG**and with skin)	65:35
8	Corn: Rice : Cowpea (G*and with skin)	60:20:20
9	Corn: Rice : Cowpea (UG**and with skin)	60:20:20
10	Corn: Rice : Cowpea (G*and with skin): Green gram	55:10:30:5
11	Corn: Rice : Cowpea (G*and with skin): Cowpea	55:10:30:5
12	Corn: Rice: Chickpea(G)*:Cowpea(G)*:Chickpea(UG**): Cowpea(UG**) : Green gram (Un**)	55:10:10:10:5:5:5

G*=Germinated, UG**=Un-germinated (Salt=7 gr, Black pepper =5 gr)

2.3. Analysis of the developed products

2.3.1. Functional properties

The extruded samples (Figure 1) were analyzed to find densities of extrudates such as tap, true and bulk densities. The samples were also analyzed for their extrudate diameter, expansion ratio (25) and expansion area (26, 27). Hardness of extruded products was determined using texture meter (28). All samples were also evaluated for their water absorption index, water solubility index (29) and water holding capacity.

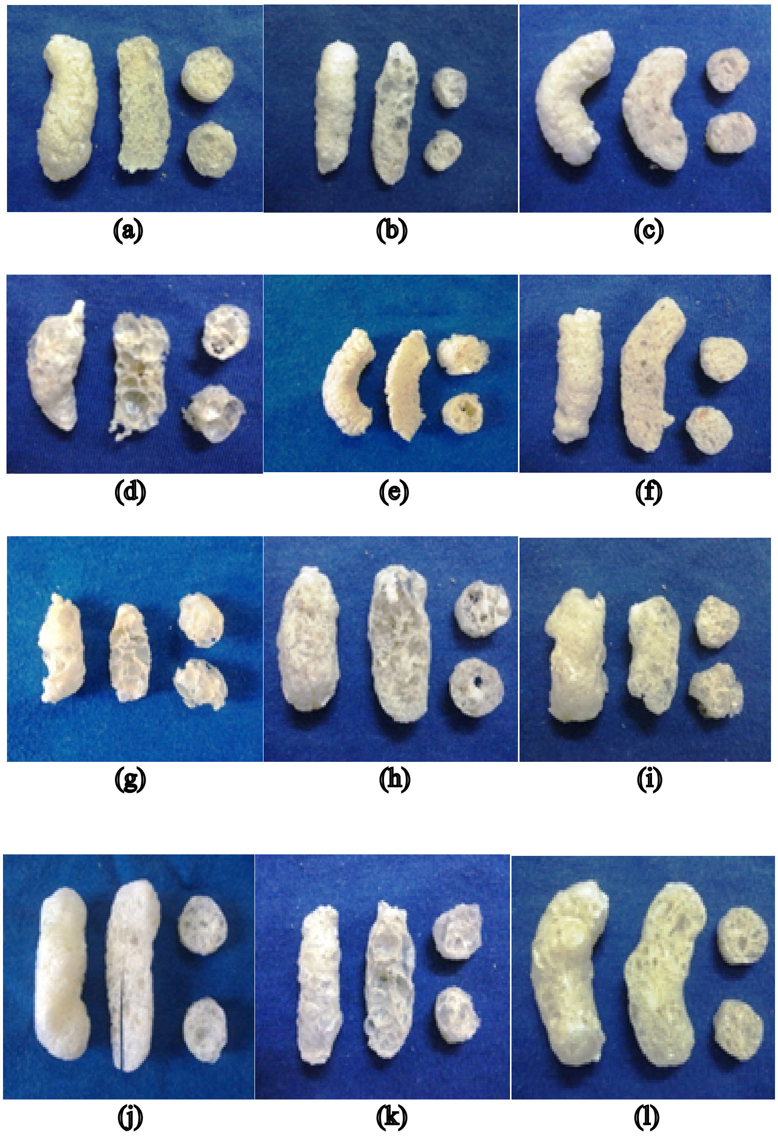

Figure 1. Figures of twelve extruded samples; a) Corn (control: I) (100%); b) Corn: Rice (control: II) (75%:25%); c) Corn: Cowpea (germinated and without skin) (75%:25%); d) Corn: Cowpea (germinated and with skin) (75%:25%); e) Corn: Cowpea (un-germinated and with skin) (75%:25%); f) Corn: Cowpea (germinated and with skin) (65%:35%); g) Corn: Cowpea (un-germinated and with skin) 60%:250%:20%); h) Corn: Rice: Cowpea (germinated and with skin (65%:35%); i) Corn: Rice: Cowpea (un-germinated and with skin) (60%:250%:20%); j) Corn Rice: Cowpea (germinated and with skin): Green gram (55%:10%:30%:5%); k) Corn: Rice: Cowpea (germinated and with skin): Cowpea (55%:10%:30%:5%); l) Corn: Rice: Chickpea (germinated and with skin): Cowpea (germinated and with skin): Chickpea: Cowpea: Green gram (55%: 10%: 10%: 10%: 5%: 5%: 5%)

2.3.2. Sensory Evaluation

Consumer acceptability studies were conducted by 100 semi-trained panel members using 9 point hedonic scale for sensory attributes like color, flavor texture and Overall acceptability (30).

2.3.3. Statistical analysis

The data was analyzed by computer using Statistical Package for Social Science (SPSS Inc Chicago IL, Version 16). The mean and standard deviation (SD) of the triplicate analyses were calculated. Quantitative variables were analyzed by one-way analysis of variance (ANOVA). When the one-way ANOVA results were significant, the Bonferroni test was performed to determine whether significant differences existed between different variables means. Significance of the differences was defined as $P < 0.05$.

3. RESULTS AND DISCUSSION

The physicochemical properties of extruded products were evaluated; functional properties such as extrudate diameter, expansion ratio, expansion area, extrudate weight, hardness, tap, true and bulk densities were assessed. Physical parameters such as water holding capacity, water solubility index, and water absorption index were also investigated.

In the current study, researchers assessed the functional properties and physical parameters of twelve extruded products by standards methods. The related data were presented in the Table 2, Table 3 and Table 4. Consumer acceptability studies were conducted using semi-trained panel members, hedonic scale for sensory attributes like color, flavor, texture and overall acceptability. These data demonstrated in Table 4.

3.1. Functional parameters

Functional parameters of extruded products have been assessed and their results reported in the Table 2. Range of the extrudate diameter, expansion ratio and expansion area of all products were 9.0 to 11.9 mm, 5.0 to 6.6 mm/mm and 2.8 to 3.7 mm/mm^2 respectively. Results of functional parameters of all formulas revealed that the extrudate diameter, expansion ratio and expansion area were significantly lower than the corn control. As it is clear in the Table 2, the extrudate diameter, expansion ratio and expansion area of extruded formula 12 were slightly lower than the corn control. The lowest amount of extrudate diameter, expansion ratio and expansion area were seen in the extruded formulas 4 and 6 (9 mm, 5mm/mm and 2.8 mm/mm^2). It should be consider that the greater expansion of products is related to implication of superior quality. The range of extruded weight in equivalent extruded products was between 0.12 to 0.17 g. Results of the extrudate weight equivalent of all formulas showed that their extrudate weight equivalent were slightly more than the corn control and extruded formula 12 (Table 2). The range of the hardness extruded products was between 10.1 to 17.25N. The results of functional parameter for all formulas were revealed that the hardness extruded formulas 12, 10 and 11were significantly lower than others (Table 2). Hardness in formula's 2 was in the highest amount compared to others. Lower amounts of extrudate weight equivalent and hardness are related to superior quality.

Table 2. Functional parameters of extruded products based on Cereals, Pulses and Legumes (Corn, Rice, Chickpea, Cowpea and Green gram)

S. No	Ingredients	Proportion (%)	Functional parameters				
			Extrudate Diameter (mm)	Expansion Ratio (mm/mm)	Expansion Area (mm/mm^2)	Extrudate Weight equivalent (g)	Hardness (N)
1	Corn (Control)	100	11.9±0.7^a	6.6±0.3^a	3.7±1.2^a	0.12±0.7^a	11.20±1.5^a
2	Corn: Rice(Control)	75:25	9.60±1.2^b	5.3±0.4^{bc}	3.0±0.4^{bc}	0.14±0.5^{ab}	17.25±1.3^b
3	Corn: Cowpea (Germinated and without skin)	75:25	9.20±0.6^{bc}	5.1±0.3^{bc}	2.8±0.5^{bc}	0.16±0.9^b	11.05±0.7^a
4	Corn: Cowpea (Germinated and with skin)	75:25	9.00±0.5^c	5.0±0.9^b	2.8±0.6^b	0.16±0.7^b	10.44±1.4^c
5	Corn: Cow Pea (Un-germinated and with skin)	75:25	9.30±0.8^c	5.2±0.6^{bc}	2.9±0.8^b	0.15±0.6^{ab}	11.08±0.9^a
6	Corn: Cowpea(Germinated and with skin)	65:35	9.00±0.5^c	5.0±0.7^b	2.8±0.7^b	0.17±0.5^b	11.12±0.6^a
7	Corn: Cow Pea (Un-germinated and with skin)	65:35	9.10±0.9^c	5.1±0.5^{bc}	2.8±0.9^b	0.16±0.3^b	11.45±1.5^a
8	Corn: Rice : Cowpea (Germinated and with skin)	60:20:20	9.50±0.7^b	5.3±0.8^{bc}	2.9±0.7^b	0.14±0.8^{ab}	11.62±1.8^g
9	Corn :Rice : Cowpea(Un-germinated and with skin)	60:20:20	9.70±0.4^b	5.4±0.3^c	3.0±0.4^{bc}	0.14±0.5^{ab}	11.8±1.4^h
10	Corn: Rice: Cowpea(Germinated and with skin):Green gram	55% : 10% : 30% : 5%	10.9±0.6^d	6.1±0.7^d	3.4±0.3^a	0.13±0.4^a	10.22±1.8^c
11	Corn: Rice: Cowpea (Germinated and with skin): Cowpea	55% : 10% : 30% : 5%	10.7±0.3^d	5.9±0.8^d	3.3±0.6^c	0.14±0.7^a	10.26±1.4^c
12	Corn: Rice: Chickpea (Germinated and with skin): Cowpea (Germinated and with skin): Chickpea: Cowpea: Green gram.	55: 10 : 10 : 10 : 5 : 5 :5	11.7±0.9^a	6.5±0.9^a	3.6±0.8^a	0.12±0.6^a	10. 1±0.4^c

Different superscripts in the same columns indicate significant difference at 5% level as shown by post hoc bonferroni test, Mean ±SD

Functional parameters namely tap, true and bulk's densities of the extruded products demonstrated in the Table 3. The tap density in the extruded products was ranged between 0.224 to 0.724g ml^{-1}. The results of tap density of all extruded formulas revealed that tap density of them were significantly lower than corn control and corn-rice control. The tap density in the extruded formula 12 was in the lowest amount (0.224 g ml^{-1}), while in the extruded formula 2 it was in the highest amount (0.724 g ml^{-1}). The values of true density in the extruded products were between 0.37 to 2.00 g ml^{-1}. The range of the bulk density in the extruded products was between 217 to 394 g cm3^{-1}. Bulk density of formulas 11(217 g cm3^{-1}) was in the lowest value, while it was in the highest amount in the extruded formula 6 and followed by extruded formula 12 (394 and 385 g cm3^{-1} respectively) (Table 3).

Table 3. Functional parameters of extruded products based on Cereals, Pulses and Legumes (Corn, Rice, Chickpea, Cowpea and Green gram)

S. No	Ingredients	Proportion (%)	Functional parameters		
			Tap density (g/ml)	True density (g/ml)	Bulk density (g/cm^3)
1	Corn (Control-1)	100	0.569±0.9^a	0.90±0.9^{ab}	328±0.1^a
2	Corn: Rice (Control-1)	75:25	0.724±0.6^b	1.50±0.9^b	340±0.7^b
3	Corn : Cowpea (Germinated and without skin)	75:25	0.490±0.3^c	1.66±0.5^{cd}	287±0.9^a
4	Corn : Cowpea (Germinated and with skin)	75:25	0.510±0.4^d	1.80±0.8^c	288±0.3^a
5	Corn : Cowpea (Un-germinated and with skin)	75:25	0.540±0.5^e	2.00±0.4^a	315±0.5^c
6	Corn : Cowpea (Germinated and with skin)	65:35	0.330±0.1^f	1.43±0.6^d	394±0.9^d
7	Corn: Cowpea (Un-germinated and with skin)	65:35	0.340±0.1^f	1.46±0.2^d	258±0.5^e
8	Corn: Rice : Cowpea (Germinated and with skin)	60:20:20	0.460±0.2^c	1.67±0.5^{cd}	299±0.9^f
9	Corn: Rice : Cowpea (Un-germinated and with skin)	60:20:20	0.550±0.8^e	1.81±0.7^c	333±0.6^g
10	Corn: Rice: Cowpea (Germinated and with skin): Green gram	55% : 10% : 30% : 5%	0.490±0.4^c	1.25±0.1^e	222±0.5^h
11	Corn: Rice: Cowpea (Germinated and with skin) : Cowpea	55% : 10% : 30% : 5%	0.400±0.6^g	1.10±0.4^e	217±0.8^i
12	Corn: Rice: Chickpea (Germinated and with skin): Cowpea (Germinated and with skin): Chickpea: Cowpea: Green gram.	55: 10 : 10 : 10 : 5 : 5 :5	0.224±0.5^c	0.37±0.8^a	385.0±0.7^j

Different superscripts in the same columns indicated significant difference at 5% level as shown by post hoc bonferroni test; Mean± SD

3.2. Physical Parameters

Results on the physical parameters (namely water holding capacity, water solubility index and water absorption index) are presented in the Table 4. The range of percent of water holding capacity (WHC) in the extruded products was between 244.0 to 379.0%. The water holding of all formulas were significantly higher than corn control ($P < 0.05$), except formula 12, that showed the lowest amount of WHC (244.0%). Water holding capacity in formula 11 was significantly highest than others ($P < 0.05$); lower value of water holding ascribe as superior quality. The range of the water solubility index (WSI) in the extruded products was between 0.25 to 0.48%. Water solubility index of all formulas were significantly more than the corn control and corn-rice control ($P < 0.05$), except formula 9, that its water solubility was similar to the corn control (0.27%, Table 4). The highest amount of WSI was observed in extruded formula 12 (0.48%, Table 4). Water absorption index (WAI) of formula 10 was in the lowest amount (4.0%). The highest amount of WAI was seen in the extruded product 12 (6.5%). The higher value of water solubility was considered as superior quality.

Table 4. Physical parameters of extruded products based on Cereals, Pulses and Legumes (Corn, Rice, Chickpea, Cowpea and Green gram)

S. No	Ingredients	Proportion (%)	Physical parameters		
			Water Holding Capacity (%)	Water Solubility Index (%)	Water Absorption Index (%)
1	Corn (Control-1)	100	250±1.6^{a}	0.27±0.8^{ad}	4.4±0.3^{a}
2	Corn: Rice (Control-1)	75:25	363±0.4^{b}	0.25±0.3^{a}	4.3±0.5^{a}
3	Corn: Cowpea (Germinated and without skin)	75:25	330±1.6^{c}	0.43±0.7^{bcd}	6.0 ±0.6^{bd}
4	Corn: Cowpea (Germinated and with skin)	75:25	340±0.6^{d}	0.40±0.5^{b}	5.5±0.5^{c}
5	Corn: Cowpea (Un-germinated and with skin)	75:25	349±0.5^{e}	0.42±0^{b}	5.9±0.7^{b}
6	Corn: Cowpea (Germinated and with skin)	65:35	360±1.8^{b}	0.46±0.4^{ce}	6.3 ±0.5^{de}
7	Corn: Cowpea (Un-germinated and with skin)	65:35	377±1.2^{f}	0.41±0.3^{b}	5.8±0.9^{c}
8	Corn: Rice: Cowpea (Germinated and with skin)	60:20:20	369±0.5^{g}	0.30±0.6^{d}	4.9±0.4^{e}
9	Corn: Rice: Cowpea (Un-germinated and with skin)	60:20:20	379±0.9^{f}	0.27±0.5^{ad}	4.4±0.7^{af}
10	Corn: Rice: Cowpea (Germinated and with skin): Green gram	55% : 10% : 30% : 5%	340±0.6^{d}	0.45±0.3^{ce}	4.0±0.5^{f}
11	Corn: Rice: Cowpea (Germinated and with skin): Cowpea	55% : 10% : 30% : 5%	379±0.5^{f}	0.45±0.2^{ce}	4.1±0.4^{f}
12	Corn: Rice: Chickpea (Germinated and with skin): Cowpea (Germinated and with skin): Chickpea: Cowpea: Green gram.	55: 10 : 10 : 10 : 5 : 5 :5	244±0.7^{c}	0.48±0.9^{e}	6.5±1.3^{e}

Different superscripts in the same columns indicated significant difference at 5% level as shown by post hoc bonferroni test; Mean ±SD

3.3. Sensory attributes

Sensory evaluation indicates the acceptability of the product. Also, sensory characteristics such as colour, flavour, texture and overall acceptability are some of the determinants of consumer acceptability and hedonic scale that were used to find the different aspect of sensory evaluation. The finished products were tested for consumer acceptability using 9 hedonic scales. The average scores that were recorded by judges are presented in the Table 5. The results of the present study revealed that colour rating of extruded formula11 (with rating of 3) was in the lowest and the highest colour rating that was observed for the extruded formula 12 (with rating of 7.2) followed by extruded formula 1 with rating of 7. Flavour is an essential attribute in consumer's opinion of food and buying assessment. Analysing of data showed that the lowest rating rate of flavour was in the extruded formula 4 (with ranting of 4.1). The highest rating rate of flavour was observed in the extruded formula 12 (rating rate was 8.0). Texture is an imperative attribute in consumer's observation of food and buying assessment. The lowest ranking of texture was observed in the extruded formula 4 with ranking rate of 6.1and it was followed by extruded formula 11 and the highest amount was observed in the extruded formula 12 with rating of 8.5. Overall acceptability in the extruded formula 7 with rate of 4.9 was in the lowest amounts among others, while it was in the highest amounts in the extruded formula 12 with ranking of 7.9.

Table 5. Sensory attributes of extruded products based on Cereals, Pulses and Legumes (Corn, Rice, Chickpea, Cowpea and Green gram)

S. No	Ingredients	Proportion (%)	Sensory attributes			
			Color	Flavor	Texture	Overall accept
1	Corn (Control-1)	100	7.0 ± 0.9^{a}	6.6 ± 1.3^{a}	7.8 ± 1.1^{a}	7.1 ± 1.5^{a}
2	Corn: Rice(Control-2)	70 : 30	6.5 ± 0.2^{b}	6.2 ± 1.1^{b}	7.5 ± 0.9^{ac}	6.7 ± 0.5^{b}
3	Corn: Cowpea (Germinated and without skin)	70 : 30	4.4 ± 0.8^{c}	5.0 ± 0.9^{c}	6.5 ± 0.8^{bd}	5.3 ± 0.9^{c}
4	Corn: Cowpea (Germinated and with skin)	70 : 30	5.2 ± 0.8^{d}	4.1 ± 1.0^{d}	6.8 ± 0.4^{b}	5.4 ± 1.3^{c}
5	Corn: Cow Pea (Un-germinated and with skin)	70 : 30	5.4 ± 0.7^{dg}	4.5 ± 0.7^{e}	7.2 ± 0.6^{c}	5.7 ± 0.8^{d}
6	Corn: Cowpea(Germinated and with skin)	65 : 35	4.8 ± 0.8^{e}	4.8 ± 0.9^{e}	6.5 ± 0.8^{bd}	5.4 ± 0.9^{c}
7	Corn: Cowpea (Un-germinated and with skin)	65 : 35	4.0 ± 0.8^{f}	4.5 ± 1.0^{e}	6.1 ± 0.9^{d}	4.9 ± 1.3^{e}
8	Corn: Rice: Cowpea (Germinated and with skin)	60 : 20 : 20	5.7 ± 0.7^{g}	5.6 ± 0.7^{f}	7.4 ± 0.6^{c}	6.2 ± 0.8^{f}
9	Corn: Rice: Cowpea(Un-germinated and with skin)	60 : 20 : 20	6.0 ± 0.5^{i}	5.0 ± 0.8^{c}	7.8 ± 0.5^{a}	6.3 ± 0.7^{f}
10	Corn: Rice: Cowpea(Germinated and with skin): Green gram	55 : 10 : 30 : 5	5.6 ± 1.2^{g}	6.8 ± 1.7^{a}	6.7 ± 1.9^{b}	6.4 ± 1.4^{f}
11	Corn: Rice: Cowpea (Germinated and with skin) : Cowpea	55 : 10 : 30 : 5	5.5 ± 1.8^{g}	6.5 ± 1.5^{a}	6.2 ± 1.0^{d}	6.1 ± 1.9^{fg}
12	Corn: Rice: Chickpea (Germinated and with skin): Cowpea (Germinated and with skin): Chickpea: Cowpea: Green gram	55: 10 : 10 : 10 : 5 : 5 :5	7.2 ± 1.9^{a}	8.0 ± 1.8^{g}	8.5 ± 1.0^{e}	7.9 ± 1.8^{h}

Note: Different superscripts in the same columns indicate significant difference at 5% level as shown by post hoc bonferroni test; Mean± SD

Our finding showed in those formula that the rice was added to pulses in order to produce a combination that was lower than corn control; similar results also reported by Pastor-cavada et al (31). Grains constituents such as starch, fat and fibre are influenced on the functional properties of final products. The physical properties and expansion characteristics of extruded snack products have an important role in the acceptability of the final product. In extrusion cooking, expansion is the primary quality parameter that is associated with product crispiness, water absorption, water solubility, and crunchiness. During extrusion cooking of biopolymers, the visco-elastic material is forced through the die so that the sudden pressure drops causes part of the water vaporize and giving an expanded porous structure. The expansion ratio of the extrudates seeks to describe the degree of puffing undergone by the dough as it exists in the extruder (32). Prinyawiwatkul et al (33) reported that the addition of protein to a starchy extrusion system may retard expansion by the increased firmness of plasticized extrudates. Bhattacharya et al (34) reported that extrudates produced from rice–Green gram blends have lower expansion ratios than rice alone. A similar finding was observed for the rice–Cowpea–groundnut blend; Cowpea and groundnut additions for rice will be resulted in a decrease in the expansion ratio (35). Their results showed that the expansion ratio was varied between 4.5 to 6.6. Our finding also depicted a decreasing in expansion ratio with increasing the percent of rice in extruded formulas. The result of expansion ratio of extrudates indicates that expansion ratio decreased with increased level of cereals starch and amount of proteins decreased in the composite mixes. This creates decreasing in expansion ratio due to the high level of protein that affects the expansion through their ability for water distribution in the matrix through their macro molecular structure. Similar findings were reported by (36, 37). The textural properties of extruded products are generally described by the hardness and crispness. The hardness of an expanded extrudate is a perception of the human being and is associated with the expansion and cell structure of the product. The maximum peak force from the texture analyser represents the resistance of the extrudate to the initial penetration and is believed to be the hardness of the extrudate (38). For extruded foods, it was desirable to have low values for hardness (39). Similar observations were also made in the present study. Bulk density is a very important parameter in the production of expanded and formed food products. Results showed that extruded formula 11 had the lowest amounts of bulk density (217 g/cm^3), while the highest amounts observed in the extruded formula 12 with 385 g/cm^3. Results of the present study showed that bulk density in the extruded formula 12 was higher than corn control and corn – rice control and it's attributed to the higher crude fiber content of formula 12 than corn control and corn rice control. Deshpande and Poshadri (37) reported that higher crude fiber in the composite flour sample would results in higher bulk density. Similar results were observed by Sawant et al (40). Our finding showed the lowest amounts of true density in the extruded formula 12 ($0.37gmL^{-1}$) and the highest amount of true density was observed in the extruded formula 6 with amount of $2.5gmL^{-1}$. Water solubility index (WSI) is measured for the amount of soluble polysaccharide released from starch component after extrusion cooking and it is related to the quantity of water soluble molecules. The results of present study revealed that extruded formula 12 had the highest amounts of WSI (0.48%) when is compared with others. In the extruded formula 2, the lowest amount of WSI was found as 0.22%. Water solubility index measures the volume occupied by the starch after swelling in excess water, which maintains the integrity of starch in aqueous dispersion. It describes the rate and extent in the component of powder material or particles dissolved in water. The water absorption index was found as extruded formula 12. A reason for increasing of WSI may be related to ingredients of extruded formula 12 in which different legumes such as Cowpea, Chickpea and Green gram that had influence on the WSI. Similar results were observed in other researches (40, 41). The lowest amount of water absorption index (WAI) was observed in the extruded formula 10 with 4.0% followed by extruded formula 11 (4.1%). The highest amount was observed in the extruded formula 12 with amount of 6.5%. The water absorption index (WAI) measures the amount of water absorbed by starch and can be used as an index of gelatinization (42). The gelatinization is the conversion of raw starch into a cooked and digestible material using water and heat. Ready-to-eat extrudates would be considered as optimum item if water absorption index and water solubility be as high as possible. The panels of semi-trained judges consisting of 100 members were given the extruded snack food samples for evaluation the sensory characteristics viz. appearance, color, taste, texture, and overall acceptability for consumer acceptability studies. It is evident that type of ingredients significantly affected the color of the extruded products. Color is an important quality factor directly related to the acceptability of food products. Color changes can give information about the extent of browning reactions such as caramelization, maillard reaction, degree of cooking and pigment degradation. Flavor is also an essential attribute in consumer's opinion of food and buying assessment. Texture is an imperative attribute in consumer's observation of food and buying assessment. Analysis of data showed extruded formula 12 had the best sensory characteristics among others formulas.

4. CONCLUSION

It is considerable that mixing of cereals, pulses and legumes along with using of different methods of processing, will improve the quality and quantity of nutrients in final products. Future research may need to conduct through enriching the flours with phytochemical sources and observing the effect of extrusion cooking.

ACKNOWLEDGMENT

The authors would like to appreciate from Dr. Kavita Waghray, Head of Department of Food Technology, University College of Technology Osmania University, Hyderabad, India, and her colleagues for their support and cooperation. First author have special thanks from the University of Medical Science and Health Services of Zahedan, Iran for supporting to conduct this investigation at Osmina University, Hyderabad, India.

FUNDING/SUPPORT

The current research is an academic research and all expenses are self-financing.

AUTHORS CONTRIBUTION

This work was carried out in collaboration among all authors.

CONFLICT OF INTEREST

The authors declared no potential conflicts of interests with respect to the authorship and/or publication of this paper.

REFERENCES

1. WHO. Childhood nutrition and progress in implementing the International Code of Marketing of Breast-milk Substitutes: WHO,Geneva, World Health Organization, 2002 (document A55/14); 2002.
2. Unicef. Improving Child Nutrtion. The achievable imperative for global progress: Unicef, www.unicef.org/publications/index.html 2013.
3. Black R, Allen L, Bhutta Z, Caulfield L, deOnis M, Ezzati M, et al. Maternal and child undernutrition: global and regional exposures and health consequences. Lancet. 2008;371:243-60.
4. Michaelsen K, Hoppe C, Roos N, Kaestel P, Stougaard M, Lauritzen L, et al. Choice of foods and ingredients for moderately malnourished children 6 months to 5 years of age. Food and Nutrition Bulletin. 2009;30(3):S343-S404.
5. Trehan I, Goldbach HS, LaGrone HS, Meuli LN, Wang GJ, Maleta RJ, et al. Antibiotics as part of the management of severe acute malnutrition. The New England Journal of Medicine. 2013;368:425- 35.
6. Sayari AA, Sheykholeslam RM, Naghavi M, AL E. Surveying different types of malnutrition in children under 5 years old in urban and rural areas, Iran, 1998. Pejouhandeh. 2001;20(5):409-16. (In Persian).
7. Ghassemi H, Harrison G, Mohammad K. An accelerated nutrition transition in Iran. Public Health Nutr , 5. 2002:149 - 55.
8. Malekzadeh JM, Hatamipour E, Afshoon E. Protein-Energy Malnutrition in School Children of Boirahmad Rural Areas, Iran. Iranian J Publ Health. 2003;32(3):41-6.
9. Sharfzadeh G, Mehrjoofard H, Raghebi S. Prevalence of Malnutrition in under 6-year Olds in South Khorasan, Iran. Iranian Journal of Pediatrics. 2010;20(4):435-41.
10. Payandeh A, Saki A, Safarian M, Tabesh H, Siadat Z. Prevalence of Malnutrition among Preschool Children in Northeast of Iran, A Result of a Population Based Study. Glob J Health Sci. 2013;5(2):208-12.
11. FAO. Targeting for nutrition resources for advancing well being. Rome: Food and Agricultural Organization. Geneva: UN; 2001.
12. Ijarotimi OS, Keshinro OO. Formulation and Nutritional Quality of Infant Formula Produced from Germinated Popcorn, Bambara Groundnut and African Locust Bean Flour. JMBFS. 2012;1(6):1358-88.
13. Nemer L, Gelband H, JHA P. Commission on Macroeconomics and Health. The evidence base for interventions to reduce malnutrition in children under five and school age children in low- and middle-income countries. CMH working paper noWG5:11. Geneva: World Health Organization; 2001.
14. Muller O, Garenne M, Kouyate B, Becher H. The association between protein - energy malnutrition, malaria morbidity and all-cause mortality in West African children. Tropical Med Int Health. 2003;8:507-11.
15. Black RE, Morris SS, Bryce J. Where and why are 10 million children dying every year? Lancet. 2003;361:2226-34.
16. FAO. Undernourishment around the world. In: The state of food insecurity in the World. Rome: Food and Agricultural Organization Geneva: UN; 2004.
17. FMOH. National policy on infant and young child feeding in Nigeria. p. 1-25, 2005.

18. Alozie YE, Iyam MA, Lawal O, Udofla U, Ani IF. Utilization of Bambara ground flour blends in bread production. Journal of Food Technology. 2009;7(4):111-4.
19. Eka BE, Abbey BW, Akaninwor JO. Nutritional Evaluation of Some Traditional Weaning Foods from Akwa Ibom State, Nigeria. Nigerian Journal of Biochemistry and Molecular Biology. 2010;25(1):65-72.
20. Bhattacharya J, Currie J, . SH. Poverty, food insecurity, and nutritional outcomes in children and adults. Journal Health Economic. 2004;23:839-62.
21. Anigo KM, Ameh DA, Ibrahim S, Danbauchi SS. Microbiological analyses of commonly used local complementary foods in North Western Nigeria. Journal Medical Sciences. 2007;7(5):875-9.
22. Muhimbula HS, Issa-Zacharia A, Kinabo J. Formulation and sensory evaluation of complementary foods from local, cheap and readily available cereals and legumes in Iringa, Tanzania. African Journal of Food Science. 2011;5(1):26-31.
23. Shrimpton R, Victora C, deOnis M, Lima R, Blossner M, Clugston G. Worldwide timing of growth faltering: implications for nutritional interventions. Pediatrics. 2001;107:E75.
24. Yagci S, Gogus F. Response surface methodology for evaluation of physical and functional properties of extruded snack. foods developed from food-by-products. J Food Eng 2008;86:122-32.
25. Alvarez-Martinez L, Kondury KP, Harper JM. General model for expansion of extruded products. Journal of Food Science. 1988; 53:609-15.
26. Kocherla P, Aparna K, Lakshmi DN. Development and evaluation of RTE (Ready to Eat) extruded snack using egg albumin powder and cheese powder. Agric Eng Int: CIGR Journal. 2012;14 (4):179.
27. Fan J, Mitchell JR, Blanchard JMV. The effect of sugars on the extrusion of maize grits: The role of the glass transition in determining product density and shape. International Journal of Food Science and Technology. 1996;31:55-65.
28. Yao N, Floros JD, Seetharaman K. Identification of important production variables affecting hard pretzel quality. Int J Food Qual. 2005;22:222-4.
29. Anderson RA. Water absorption and solubility and amylograph characteristics of roll-cooked small grain products. Cereal Chemistry. 1982;59:265-9.
30. Meilgaard M, Civille GV, Carr BT. Sensory Evaluation Techniques.Third ed.CRC Press, Boca Raton. 1999.
31. Pastor-Cavada E, Drago SR, González RJ, Juan R, Pastor JE, Alaiz M, et al. Effects of the addition of wild legumes (Lathyrus annuus andLathyrus clymenum) on the physical and nutritional properties of extruded products based on whole corn and brown rice. Food Chemistry. 2011;128(4):961–7.
32. Thymi S, Krokida MK, Pappa A, Maroulis ZB. Structural properties of extruded corn starch. J Food Eng. 2005;68:519-26.
33. Prinyawiwatkul W, McWatters KH, Beuchat LR, Phillips RD. Cowpea flour: A potential ingredient in food products. Critical Reviews in Food Science and Nutrition. 1996;36:413-36.
34. Bhattacharya S. Twin-screw extrusion of rice-green gram blend: Extrusion and extrudate characteristics. Journal of Food Engineering. 1997;32:83-99.
35. Asare EK, Sefa-Dedeh S, Sakyi-Dawson EO, Afoakwa EO. Application of Response Surface Methodology for Studying the Product Characteristics of Extruded Rice-cowpea-groundnut Blends. International Journal of Food Science and Nutrition. 2004;55 (5):431-9.
36. Singh R, Singh G, Chauhan GS. Effect of incorporation of defatted soy flour on the quality of biscuits. J Food Sci Technol. 1996;33:355-7.
37. Deshpande HW, Poshadri A. Physical and sensory characteristics of extruded snacks prepared from Foxtail millet based composite flours. International Food Research Journal. 2011;18:751-6.
38. Ding QB, Ainsworth P, Plunkett A, Tucker G, Marson H. The effect of extrusion conditions on the functional and physical properties of wheat-based expanded snacks. J Food Eng. 2005;73:142-8.
39. Mendonça S, Grossmann MVE, R Verhé R. Corn bran as a fibre source in expanded snacks. Lebensm-Wiss u-Technology. 2000;33:2-8.
40. Sawant AA, Thakor NJ, Swami SB, Divate AD. Physical and sensory characteristics of Ready-To-Eat food prepared from finger millet based composite mixer by extrusion Agriculture Engineering International: CIGR Journal 2013.
41. Shirani G, Ganesharanee R. Extruded products with fenugreek (Trigonellagraecium) Chick pea and Rice: physical properties, sensory acceptability and glycemic index. Journal of ood Engineering. 2009;90:45-52.
42. Anderson RA, Conway HF, Pfeife VF, Gri_n EL. Gelatinization of corn grits by roll and extrusion cooking. Cereal Science Today. 1969;14:4-12.