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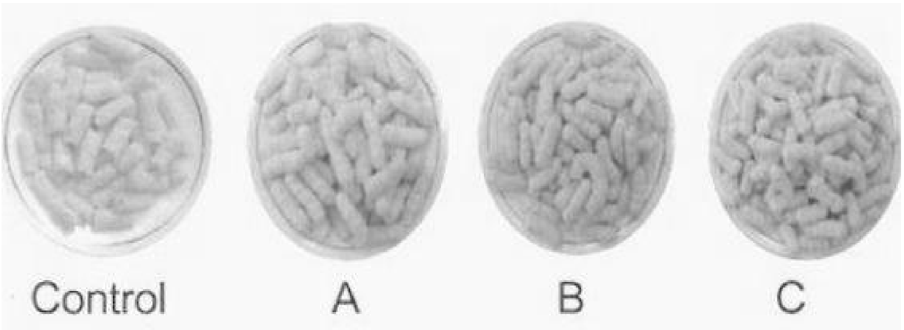

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RESEARCH ARTICLE

DEVELOPMENT AND QUALITY EVALUATION OF VALUE ADDED EXTRUDED SNACKS BY SUPPLEMENTING AMARANTH AND GUAR GUM IN MIXED CEREAL FLOUR FORMULATION CONSTITUTING MAIZE, RICE AND WHEAT

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ABSTRACT

Value added extruded snacks were developed by incorporating amaranth flour (raw and roasted) at 20, 40 and 60%, amaranth protein concentrate (APC) at 10, 20 and 30% and guar gum at 0.5 and 1.0 % to the standardized mixed cereal flour composition, prepared with maize: rice: wheat (80:10:10) extruded at moisture content 12% and feed rate 13 kg/hr (control). Developed snacks were evaluated for physical properties, functional characteristics, sensory attributes and proximate composition. Effect of incorporation of different levels of amaranth and guar gum on quality parameters of RTE-snacks was studied. It was found that, incorporation of higher level of amaranth flour and amaranth protein concentrate in the mixed cereal formulation increased the solubility index, bulk density and hardness and decreased the absorption index, expansion ratio and sectional expansion index of extrudates whereas with incorporation of guar gum, increase in expansion ratio, sectional expansion index and decrease or no change in hardness and bulk density of RTE snacks was observed, respectively. However, RTE snacks containing 20% APC, 40% raw or 60% roasted amaranth flour were adjudged 'liked very much' by the judges. The snacks prepared with amaranth contained higher protein, fat and crude fibre content as compared to control snacks prepared without amaranth. Study indicated that amaranth flour (raw) upto 40%; amaranth flour (roasted) upto 60%; protein concentrate upto 20% and guar gum (0.5-1.0%) can be supplemented to mixed cereal flour for the preparation of value added ready-to-eat extruded snacks.

INTRODUCTION

Amaranth, a pseudocereal underutilized crop has been attracting worldwide attention with its multipurpose uses. It is a dicotyledonous C_4 plant belonging to genus amaranthus of the family amaranthaceae. Amaranth seeds are rich source of protein, fats, fiber and minerals such as calcium, potassium, phosphorus (Bodroza *et al.*, 2003). Grain amaranth contains 5% lysine and 4.4% sulfur amino acids, which are the limiting amino acids in other grains (Senft, 1980). Its grains have attractive chemical composition, superior nutritive value, and high quality oil (including squalene) which has been found to act as an anticancer agent and have hypocholesteromic effects (Berghofer & Schoenlechner, 2002). Besides its nutritional value, it has medicinal importance too. It does not cause allergic reactions in intestinal mucosa and has tendency to stimulate insulin production (Guerra-matias, 2005). It can be processed into a variety of ways, which includes cooking, steaming, blanching, stir-frying and baking (Oke, 1983, Saunders and Becker, 1984). Processing may affect the protein quality of amaranth grain and more severe heat treatments might damage the protein (Pedersen *et al.*, 1987). Extrusion cooking process for amaranth resulted in the protein nutritional quality that was comparable to casein (Mendoza *et al.*, 1987). Extruded amaranth grain exhibited better nutritional value than raw amaranth and the product required no additional cooking prior to consumption (Bressani, 1992). Extrusion is a high-temperature short-time process which have minor effects on natural colors and flavours of foods while inactivating undesirable enzymes, lowering anti-nutritional factors and sterilizing the product (Fellows, 2000; Guy, 2001). Due to nutritional awareness, consumers today are becoming more cautious and are switching to healthier food habits. Thus, there is need to introduce new range of nutritive food products (Narayan *et al.*, 2009) with the addition of sources with high nutraceutical characteristics. The underutilized plant Amaranth has promising economic, nutritional and medicinal value and can be an ideal nutritional supplement in cereal-based diets. However, most of the extruded products are mainly made from refined flour/semolina and hence are depleted of fibre, minerals and nutrients, which is a cause of number of human diseases like gastrointestinal cancers, ulcers, obesity, cardiac diseases etc (Smitha and Mishra, 2008). Fibre content can be increased by incorporation of high fibre sources such as guar gum. It is effective in promoting regular bowel movement, relieves

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constipation and chronic related functional bowel ailments and improves the quality of products (Rana, 2006). Development of new products from amaranth will expand utilization of this raw material for human consumption. Thus, the objective of the study was to utilize amaranth and guar gum to develop RTE snacks and study the effect of their addition on physical, functional and sensory properties of prepared value added extrudates.

MATERIAL AND METHODS

Procurement of materials

Wheat variety WH-147 was procured from the Department of Plant Breeding, CCSHAU, Hisar. Maize variety HPQM-I was procured from the Regional Research station, Uchani, Karnal. Amaranth seeds and broken rice were procured from local market, Hisar. Guar gum was obtained from Merck limited, Worli Mumbai.

Preparation of amaranth flour

Amaranth grains were cleaned for extraneous matter and flour was prepared by milling the clean grains in Brabander Quardamat Junior Mill. The grains were milled directly as such and after roasting at 150°C for 5-6 min.

Preparation of Amaranth Protein Concentrate

Amaranth Protein Concentrate (APC) was prepared by using Acid Leaching Process (Liu, 1997) with slight modification. For preparation of APC, ten g amaranth flour was weighed and transferred into clean dry conical flask. To this, 100 ml water was added and mixed. The pH was set at 4.5 with the help of 1N HCl to remove soluble carbohydrates. The supernatant was discarded and residue containing protein was neutralized (pH 7.0), by adding 1N NaOH. Residues were washed with water and centrifuged again. The decanted residue was frozen at -20°C in freezer and then dried at 60°C for 12 hrs. The obtained dry matter, Amaranth protein concentrate was weighed and stored in plastic bottles till further use. %Yield was calculated by dividing the weight of the concentrate to the weight of flour multiplied by 100.

Chemical evaluation of grains/flour

The flour samples of wheat, rice, maize, amaranth and protein concentrate were analyzed for proximate composition (AOAC, 1995), mineral content (Ca & Fe) and total dietary fibre (AOAC 1995). Amaranth grains were also analyzed for β-carotene (AOAC, 1980) and phytate content (Haug and Lantzsch, 1983).

Extrusion process for preparation of control RTE snack

The maize, wheat and rice flour blends were first standardized using response surface methodology (RSM) which is a statistical package of design-expert version 8.01 (Stat-Ease Inc., Minneapolis, MN, USA). Mixed grain (control) RTE snacks containing feed composition 80:10:10 (maize: wheat: rice) extruded at moisture content 12% and feed rate 13 kg/hr were found most acceptable from 20 experimental combinations given by RSM. The extrudates were prepared using BTPL lab model twin screw extruder where material was heated to 100-150ºC temperature for 10-20 sec and finally forced to the nozzle. The pressure at die nozzle varied from 20-40 atmospheres. The extrudates were cuts into pieces by the rotating cutter fixed at the nozzle and extrudates were collected in a trough.

Preparation of value added RTE extruded snacks

For the preparation of value added ready to eat extruded snacks incorporation of two types of Amaranth flour (raw and roasted) at 20, 40 and 60%, of and amaranth protein concentrate at 10, 20 and 30% was done in standardized formulation of maize, wheat and rice flour, 80:10:10. Guar gum (0.5% and 1.0%) was then added to the formulation obtained with acceptable level of amaranth flour and amaranth protein concentrate. [Plate 1-6]

Quality evaluation of RTE-snacks

Bulk density: The bulk density was determined according to the method of Pan *et al*. (1998) by volumetric method. 100 pieces of extrudates (about 2 cm in length) were placed in a 500 ml graduated measuring cylinder. The bottom of the cylinder was tapped gently on a laboratory bench until there was no further reduction in sample volume. The volume and weight was noted and bulk density was calculated by dividing weight of sample to volume

Expansion ratio: It is ratio of cross-sectional diameter of extrudates (De) and that of die opening of the extruder (Dd) which were determined using vernier caliper.

Sectional Expansion Index (SEI): It was determined by the method given by Alvarez-Martinez *et al*. (1988). SEI was calculated by dividing the cross sectional areas of the RTE snacks (De) by the cross sectional areas of the extruder die opening (Dd) and expressed as:

$$\mathbf{SEI = (De/\ Dd)^2}$$

Texture

Texture of ready to extruded snacks was assessed using TAXT plus Texture analyzer in triplicates using 35 mm cylinder probe (CP/35) with 5 Kg load cell. The force required to break the extruded snacks was considered as hardness of snacks.

Water absorption index

WAI of the snacks was determined by method outlined by Anderson *et al* (1969). 2.5 g of ground sample was suspended in 30 ml of distilled water at 30°C in a 50 ml tarred centrifuge tube. The contents were stirred intermittently over 30 minutes period and centrifuged at 3000 × g for 10 minutes. The supernatant liquid was poured carefully into tarred evaporating dish. The remaining gel was weighed and WAI was calculated as the grams of gel obtained per gram of solid.

Water solubility index (WSI)

WSI was determined from the amount of dried solids recovered by evaporating the supernatant from the water absorption index test described above (Anderson *et al.*, 1969). It was calculated by dividing weight of the dissolved solid in supernatant by weight of dry solids multiplied by 100.

Sensory evaluation

Extrudates were given auxiliary treatment with spice mixture. Extrudates were evaluated for color and appearance, aroma, texture, taste using 9- point Hedonic scale by a panel of eight semi-trained judges. Average of the scores for all the sensory characteristics was expressed as overall acceptability score.

Nutritional evaluation of control and value added ready to eat extruded snack

Acceptable ready to eat extruded snacks were evaluated for protein, fat, fibre, ash, carbohydrates and energy value using standard methods of (AOAC, 1995).

Statistical Analysis

The data was analyzed by ANOVA using CRD for amaranth and guar gum based value added ready to eat snacks.

RESULTS AND DISCUSSION

Chemical composition

The results indicated that protein, fat, ash and crude fibre content of wheat, maize grits and rice ranged from 7.8- 12.4 %, 0.72-4.4%, 0.49-1.51% and 0.36-2.37%, respectively (Table 1). Amaranth contained higher content of protein, fat, minerals and crude fibre than wheat, maize and rice. The results obtained for composition of amaranth flour are in agreement with those reported by previous studies with regard to protein and lipid according to Berghofer & Schoenlechner, (2002) and Capriles *et al*. (2006). Amaranth lipids are characterized by a high degree of unsaturation, with a very high level of linoleic acid, which is desirable from a nutritional point of view (Alvarez-Jubete *et al.*, 2009). Amaranth flour contained appreciable amount of iron (6.1 mg/100g), calcium (139 mg/100g) and total dietary fibre (15.38%) [Table 2]. The mineral content of amaranth flour was higher than wheat, maize and rice. Processing of the amaranth to prepare protein concentrate with 30.6% protein content resulted in decrease of fat, ash and fibre content (Table 1).

Yield of protein concentrate was 47%. Amaranth is also endowed with phytates and tannins. Amaranth grain contained 1.2 mg β-carotene, 964 mg phytate and 164.5 mg tannin per 100 g. Bressani, (2003) reported phytate and tannin content as 1.03g and 0.18g per 100g, respectively. The natural bioactive compounds like phenolics, carotenoids, phytates, phytosterols, etc. have been reported to exhibit many health benefits including excellent antioxidant property (Scalbert *et al.*, 2005). Thus, the inclusion of amaranth can improve nutritional quality of conventional cereal based food products.

Effect of incorporation of amaranth flour and protein concentrate on quality of value added RTE snacks

Although the nutritional properties are important, the consumer acceptability of the snacks depends mainly on the physical and organoleptic properties of the snacks measured as expansion ratio, density, texture, appearance and their flavour. These parameters are related to the proportion and type of the available starch, which affects the number and size of air cells developed during extrusion.

Effect on physical characteristics

Control and value added snacks were assessed for physical characteristics viz. bulk density, expansion ratio, and sectional expansion index and the data has been presented in Table 3.

Expansion ratio, sectional expansion index, bulk density and hardness of control RTE snacks was 3.01, 9.06 mm, 0.067 g/cc and 4.16 kg, respectively. Results indicated that increased concentration of amaranth flour, reduced the expansion ratio and sectional expansion index of the extrudates and increased the density of extrudates due to its reduced expansion properties as compared to corn. As a result, the RTE snacks prepared with 60% raw amaranth flour were dense and hard. Extrudate density was inversely related to overall product expansion. Ilo *et al.* (1999) indicated that it is difficult to produce expanded products by extrusion cooking at higher levels of amaranth, due to its high fat content (6-8% in whole grain). Fat provides a powerful lubricant effect in extrusion cooking and reduced product expansion. Faubion and Hoseney (1982) also reported that 1g/100g lipid addition decreased shearing and breaking strength of extrudates; however, Pan *et al.* (1992) reported a positive effect of oil addition (1-5g/100g) on shear force of rice extrudates. These findings agree with the results of this study i.e. amaranth flour (raw) can be used upto 40% to prepare value added ready-to-eat extruded snacks because further increase in the level of amaranth flour resulted in higher bulk density and harder product.

Table 1 Proximate Composition and energy value of selected cereals, amaranth grains and amaranth protein concentrate

Samples	Moisture (%)	Protein (%)	Fat (%)	Ash (%)	Crude fiber (%)	Carbohydrate (%)	Energy*
Wheat	11.9±0.05	12.4±0.27	2.2±0.15	1.5±0.05	1.6±0.08	82.24±0.23	350.8
Maize	10.8±0.05	10.52±0.25	4.4±0.13	1.5±0.05	2.37±0.006	81.16±0.26	350.7
Rice	12.9±0.05	7.8±0.25	0.72±0.03	0.49±0.05	0.36±0.009	90.63±0.21	400.2
Amaranth	11.7±0.08	13.9±0.47	5.76±0.14	3.9±0.05	4.23±0.14	72.15±0.90	349.1
APC	8.6±0.49	30.6±0.64	2.73±0.08	1.3±0.05	2.56±0.12	60.41±0.72	388.6
CD at 5%	0.72	1.30	0.37	0.74	0.29	1.75	-

*calculated by factorial method
Maize - HPQM -I,
Wheat - variety WH-147,
APC - Amaranth protein concentrate
Values are ± S.D of three replicates

Similarly, with incorporation of amaranth protein concentrate (10, 20 and 30%) and roasted amaranth flour (20, 40 and 60%) decreased expansion ratio and sectional expansion index of the extrudates and increased density and hardness of extrudates was observed.

Table 2 Iron, Calcium and total dietary fiber (TDF) of selected cereals, amaranth and amaranth protein concentrate (on DM basis)

Sample	Iron (mg/100g)	Calcium (mg/100g)	TDF (%)
Wheat	5.9±2.0	17±0.6	13.1±0.05
Maize grits	2.74±0.17	15.4±0.2	14.9±0.62
Broken rice	2.8±0.4	10.3±0.3	10.64±0.63
Amaranth	6.1±0.1	139±1.5	15.38±0.23
APC	-	-	11.56±0.29

Maize – HPQM- I,
- Not Analyzed
Wheat – variety WH-147
APC - Amaranth protein concentrate
Values are ± S.D of three replicates

Table 3 Effect of incorporation of various levels of amaranth flour (raw and roasted) and amaranth protein concentrate on physical characteristics of ready-to eat value added extruded snacks

Extruded snacks L.S		Expansion ratio	Sectional expansion index (SEI)	Bulk density (g/cc)	Texture (Kg)
Control*	0	3.01±0.006	9.06±0.03	0.067±0.001	4.16±0.04
Amaranth Flour (Raw)	20	2.85±0.04	8.13±0.23	0.064±0.002	2.85±0.04
	40	2.43±0.04	5.91±0.22	0.075±0.002	2.85±0.04
	60	2.1±0.06	4.43±0.28	0.091±0.002	2.85±0.04
CD at 5%		0.15	0.71	0.005	0.52
Control*	0	3.01±0.006	9.06±0.03	0.067±0.001	4.16±0.04
Amaranth Flour (Roasted)	20	2.60±0.03	6.76±0.16	0.057±0.001	5.28±0.30
	40	2.56±0.02	6.57±0.14	0.073±0.002	6.52±0.19
	60	2.43±0.07	5.93±0.37	0.089±0.002	9.25±0.20
CD at 5%		0.14	0.72	0.005	0.68
Control*	0	3.01±0.006	9.06±0.03	0.067±0.001	4.16±0.04
Amaranth protein concentrate	20	2.84±0.04	8.07±0.03	0.060±0.002	5.20±0.39
	40	2.53±0.04	6.45±0.24	0.076±0.03	5.62±0.18
	60	2.35±0.01	5.54±0.05	0.087±0.001	7.62±0.19
CD at 5%		0.108	0.57	0.006	0.79

Control is standardized ready to eat extruded snack prepared from blends of maize, wheat and rice in 80:10:10 proportion
Values are mean ± SD of three replicates. L.S.: Level of Supplement

Effect on sensory attributes

Mean score for color and appearance, taste, texture, aroma, and overall acceptability of control extrudates prepared by using maize, wheat and rice in 80:10:10 were 8.2, 8.5, 8.2, 8.0 and 8.2, respectively (Table 4). No significant changes in mean score for all the sensory attributes except taste of ready-to-eat extruded snacks was witnessed with the use amaranth flour (raw and roasted) and amaranth protein concentrate in the formulations. Scores for taste and overall acceptability decreased significantly with the use of 60% amaranth flour and 30% amaranth protein concentrate. Sensory evaluation of control and experimental RTE-snacks showed that RTE-snacks supplemented with 40% amaranth flour and 20% protein concentrate were 'liked very much' by the judges [Plate 1-3]. RTE-snacks containing 40% raw amaranth flour, 60% roasted amaranth flour and 20% protein concentrate was used for incorporation of guar gum (0.5, 1.0%) in the formulation of RTE-Snacks. This indicates that amaranth flour can be added up to 40% in the RTE-Snacks without affecting the sensory attributes of snacks.

Effect on functional characteristics

Water absorption index and Water solubility index of value added extrudates

The WAI measures the volume occupied by the granule or starch polymer after swelling in excess water. While the WSI determines the amount of free polysaccharide or polysaccharide released from the granule after addition of excess water (Sriburi & Hill, 2000).

With incorporation of amaranth flour i.e. raw and roasted (20-60%) and amaranth protein concentrate (10-30%), gradual decrease in water absorption and increase in water solubility index was noticed as compared to control extrudates which were prepared by blending with maize, wheat and rice flour in 80:10:10 ratio; WAI, WSI ranged from 4.13-6.07, and 31.95-20.0, respectively.

Table 4 Mean score for sensory characteristics of value added RTE-Snacks prepared by incorporating various levels of amaranth flour and amaranth protein concentrate

Extruded snacks L.S %		Colour & appearance	Taste	Texture	Aroma	Overall Acceptability
Control*	0	8.2±0.16	8.5±0.18	8.2±0.16	8.0±0.00	8.2±0.09
Amaranth Flour (Raw)	20	8.1±0.12	8.2±0.16	8.0±0.00	7.8±0.12	8.06±0.04
	40	8.3±0.28	8.2±0.25	8.1±0.12	7.7±0.16	8.1±0.12
	60	8.0±0.00	7.6±0.18	7.7±0.16	7.5±0.18	7.7±0.12
CD at 5%		N.S	0.58	N.S	N.S	0.29
Control*	0	8.2±0.16	8.5±0.18	8.2±0.16	8.0±0.00	8.2±0.09
Amaranth Flour (Roasted)	20	8.0±0.00	8.2±0.12	8.1±0.12	8.1±0.12	8.1±0.04
	40	8.2±0.16	8.6±0.18	8.4±0.18	8.3±0.18	8.3±0.06
	60	7.8±0.12	8.0±0.00	7.9±0.12	8.1±0.16	7.9±0.07
CD at 5%		N.S	0.42	N.S	N.S	0.21
Control*	0	8.2±0.16	8.5±0.18	8.2±0.16	8.0±0.00	8.2±0.09
Amaranth protein concentrate	20	8.2±0.16	8.0±0.00	8.1±0.12	8.0±0.00	8.1±0.09
	40	8.3±0.18	8.1±0.12	8.2±0.16	8.1±0.22	8.2±0.11
	60	7.7±0.16	7.1±0.16	8.0±0.00	8.0±0.00	7.7±0.06
CD at 5%		N.S	0.40	N.S	N.S	0.24

Control is standardized ready to eat extruded snack prepared from blends of maize, wheat and rice in 80:10:10 proportion
Values are mean ± SD of eight replicates using 9-point hedonic scale L.S.: Level of Supplement

Significant decrease in water absorption index and increase in solubility index was witnessed with every 20% increase in amaranth flour concentration in the formulation. Similar trend was followed by incorporation with roasted amaranth flour and amaranth protein concentrate. Results indicate that higher the concentration of amaranth flour and concentrate higher the solubility index and lower the absorption index. This was due to very small size of starch granules (3-8 µm) which exhibits lower swelling power, high solubility and greater water uptake. (Saunders and Becker, 1984)

Effect of incorporation of guar gum on quality of RTE snacks

Effect on physical characteristics

Inclusion of guar gum (0.5 and 1%) in the best acceptable formulation of raw amaranth flour (40%), roasted amaranth flour (60%) and protein concentrate (20%) improved the physical properties of extrudates. Data indicated (Table 5) that value added ready-to-eat extruded snacks prepared with raw amaranth flour (40%) had 2.43 expansion ratio, 5.91 mm sectional expansion index, 0.075 g/cc bulk density and 4.62 Kg hardness. Extruded snacks prepared with roasted amaranth flour (60%) had 2.43 expansion ratio, 5.93 mm sectional expansion index, 0.089 g/cc bulk density and 9.25 Kg hardness. While extruded snacks prepared with amaranth protein concentrate, (20%) had 2.53expansion ratio, 6.45 mm sectional expansion index, 0.076 g/cc bulk density and 5.62 Kg force/hardness. With incorporation of guar gum, increase in expansion ratio, sectional expansion index and decrease or no change in hardness and bulk density of RTE snacks was observed, respectively. These results are in agreement with the findings of Ravindran *et al*. (2011) who evaluated the effects of three galactomannans (guar gum, fenugreek gum and locust bean gum) on the physical nutritional characteristics and sensory acceptability of pea–rice based extruded products. Low density foamed structures with large cells and thin cell walls are characteristics of well expanded extrudates. However, Lue *et al*. (1991) have shown that fibre in the raw material interferes with bubble expansion and, reduces the formation and retention of expanded air pockets. It was anticipated that the expansion will be reduced by higher gum addition through prematurely breaking up the expanding matrix film and also by the fibre effect of competing for free water found in the matrix, thus lowering its expansion capabilities.

Table 5 Effect of incorporation of various levels of guar gum and acceptable level of amaranth flour and amaranth protein concentrate on physical characteristics of ready-to eat value added extruded snacks

Extruded snacks	L.S. (%)	Expansion ratio	Sectional Expansion Index (mm)	Bulk density (g/cc)	Texture (kg)
Control I	0	2.43±0.04	5.91±0.22	0.075±0.002	4.62±0.25
Guar gum	0.5	2.80±0.05	7.84±0.33	0.066±0.001	3.39±0.09
	1.0	2.59±0.11	6.77±0.56	0.070±0.001	3.24±0.19
CD at 5%		0.27	1.42	N.S	0.48
Control II	0	2.43±0.02	5.93±0.14	0.089±0.002	9.25±0.19
Guar gum	0.5	2.96±0.05	8.76±0.34	0.054±0.001	4.41±0.10
	1.0	2.71±0.03	7.36±0.18	0.068±0.001	4.60±0.24
CD at 5%		0.15	0.85	N.S.	0.57
Control III	0	2.53±0.04	6.45±0.24	0.076±0.003	5.62±0.18
Guar gum	0.5	3.06±0.03	9.39±0.23	0.064±0.001	4.63±0.19
	1.0	2.64±0.02	6.94±0.12	0.068±0.001	4.95±0.24
CD at 5%		0.13	0.74	N.S.	0.63

Control I is ready to eat extruded snack prepared with acceptable level of raw amaranth flour (40%)
Control II is ready to eat extruded snack prepared with acceptable level of roasted amaranth flour (60%)
Control III is ready to eat extruded snack prepared with acceptable level of amaranth protein concentrate (20%)
Values are mean ± SD of three replicates
L.S.: Level of Supplement

Effect on sensory attributes

Mean scores for color and appearance, taste, texture, aroma and overall acceptability has been presented in Table 6. With incorporation of guar gum along with formulation containing 40% amaranth flour (raw) no significant changes were observed for all the mean scores. Similar trend was followed for all the sensory characteristics of RTE snacks prepared by incorporation of guar gum (0.5-1.0%) in acceptable formulation containing 60% amaranth flour (roasted) except mean scores for taste and overall acceptability. Guar gum can be added in the formulation to improve the texture of the extruded RTE-snacks without affecting the organoleptic qualities of the product [Plate 4-6].

Proximate composition

Results (Table 8) indicate that control ready-to-eat extruded snack contained 10.4% protein, 3.8% fat, 1.3% ash, 2.2% crude fibre and 82.1 g/100g carbohydrates.

Table 6 Mean score for sensory characteristics of value added ready to eat extruded snacks prepared by incorporating various levels of guar gum and acceptable levels of amaranth flour and protein concentrate

Extruded snack	L.S. (%)	Color and appearance	Taste	Aroma	Texture	Over all acceptability
Control I	0	8.3±0.18	8.3±0.25	7.6±0.16	8.1±0.12	8.1±0.12
Guar gum	0.5	8.0±0.18	8.1±0.22	7.9±0.12	8.2±0.12	8.0±0.08
	1.0	7.8±0.16	7.9±0.12	7.9±0.12	8.1±0.12	7.9±0.06
CD at 5%		N.S	N.S	N.S	N.S	N.S
Control II	0	7.8±0.12	8.0±0.00	7.9±0.12	8.1±0.16	7.9±0.07
Guar gum	0.5	7.9±0.22	8.0±0.00	8.1±0.12	8.1±0.12	8.0±0.04
	1.0	8.0±0.00	8.4±0.18	8.1±0.12	8.0±0.18	8.2±0.08
Control III	0	8.4±0.18	8.1±0.12	8.1±0.22	8.3±0.16	8.2±0.11
Guar gum	0.5	8.1±0.12	7.9±0.12	8.0±0.00	7.9±0.12	7.9±0.007
	1.0	8.0±0.00	7.8±0.16	7.9±0.12	7.6±0.16	7.8±0.08
CD at 5%		N.S	N.S	N.S	N.S	0.27

Control I is ready to eat extruded snack prepared with acceptable level of raw amaranth flour (40%)
Control II is ready to eat extruded snack prepared with acceptable level of roasted amaranth flour (60%)
Control III is ready to eat extruded snack prepared with acceptable level of amaranth protein concentrate (20%)
Values are mean ± SD of eight replicates response using 9-point Hedonic scale

Amaranth based RTE snacks

Plate 1 Value added RTE snacks prepared by incorporating 0(control), 20(A), 40(B), 60(C) Per cent of raw amaranth flour

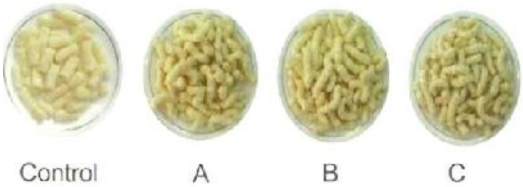

Plate 2 Value added RTE snacks prepared by incorporating 0(control), 20(A), 40(B), 60(C) percent of roasted amaranth flour

Plate 3 Value added RTE snacks prepared by incorporating 0(control), 10(A), 20(B), 30(C) percent of amaranth protein concentrate

Table 7 Water absorption and Water solubility index of value added RTE-Snacks prepared by incorporating various levels of amaranth flour and amaranth protein concentrate

Extruded snack	**L.S. (%)**	**Water absorption index**	**Water solubility index**
Control	0	6.07±0.05	20.0±0.50
Amaranth flour (raw)	20	4.84±0.08	25.1±0.60
	40	4.50±0.13	26.5±0.48
	60	4.39±0.07	27.8±0.30
CD at 5%		0.30	1.78
Control	0	6.07±0.05	20.0±0.50
Amaranth flour (roasted)	20	4.76±0.22	27.8±0.34
	40	4.42±0.20	29.0±0.26
	60	4.13±0.01	31.95±0.74
CD at 5%		0.50	1.65
Control	0	6.07±0.05	20.0±0.50
APC	10	4.64±0.07	28.0±0.57
	20	4.63±0.04	28.7±0.44
	30	4.29±0.03	28.1±1.10
CD at 5%		0.18	2.34

Control is standardized ready to eat extruded snack prepared from blends of maize, wheat and rice in 80:10:10 proportion
Values are mean ± SD of three replicates

Guar gum based RTE snacks

Plate 4 RTE snacks prepared by incorporating 0.5(A), 1.5(B) percent guar gum along with 40% amaranth flour (raw)

Plate 5 RTE snacks prepared by incorporating 0(control), 0(control), 0.5(A), 1.5(B) percent guar gum along with 60% roasted amaranth flour

Plate 6 RTE snacks prepared by incorporating 0(control), 0.5(A), 1.5(B) percent guar gum along with 20% amaranth protein concentrate

Table 8 Proximate composition and energy value of control and value added ready to eat snacks prepared by incorporating guar gum, amaranth flour and protein concentrate

RTE snacks	Protein (%)	Fat (%)	Ash (%)	Crude fibre (%)	Carbohydrate (%)	Energy* (kcal/ 100g)
Control	10.4±0.1	3.8±0.07	1.3±0.04	2.2±0.03	82.1±0.03	404
Value added RTE I	12.3±0.30	4.8±0.07	2.4±0.07	2.8±0.04	77.5±0.34	402
RTE II	14.6±0.07	4.6±0.15	3.2±0.05	3.7±0.03	73.9±0.18	395
RTE III	14.7±0.11	3.7±0.03	1.4±0.15	2.2±0.09	78±0.19	404
C.D. at 5%	0.58	0.31	0.17	0.11	0.70	-

Value-added RTE I is ready to eat extruded snack obtained with acceptable level of raw amaranth flour (40%) RTE II is ready to eat extruded snack obtained with acceptable level of roasted amaranth flour (60%)
RTE III is ready to eat extruded snack obtained with acceptable level of amaranth protein concentrate (20%) *calculated by factorial method
Values are ± S.D of three replicates

Value added RTE snacks (RTE I and RTE II) prepared with incorporation of amaranth flour (raw and roasted) contained significantly higher protein, fat, ash, fibre content as compared to control. These snacks contained 16-28%, 49-59% and 21-40% more protein, fat, ash and crude fibre, respectively. RTE snacks (III) prepared with incorporation of amaranth protein concentrate contained 29% higher protein than control. It was due to higher nutritional composition of amaranth. Jagreuzi *et al*. (2010) reported proximate composition of amaranth and corn snacks and the percentage of fatty acids. It revealed that amaranth snacks contained higher protein, fat and fibre content than maize snacks. Discussion regarding proximate composition revealed that extrusion cooking of amaranth in combination with cereal grains such as maize, wheat and rice can be used to produce nutritionally balanced products.

CONCLUSION

It is not possible to produce direct expanded products by extrusion cooking of the whole amaranth grain because of their high fat content which reduces product expansion. Additional starch or defatted amaranth fractions may be used in the production of expanded amaranth based products. An, attempt has been made to extrusion cook blends made from amaranth seeds and one or more cereal flour combination to produce nutritionally balanced extruded snacks. Amaranth flour can be processed to prepare flour and amaranth protein concentrate and be incorporated upto 40% (raw amaranth flour); 60% (roasted amaranth flour) and 20% (amaranth protein concentrate) into pre standardized mixed cereal flour formulation containing 80% maize, 10% wheat and rice each. Guar gum addition, also improved the physical characteristics of RTE-snack and sensory evaluation showed no significant changes in the attributes except, taste. As a result, guar gum (0.5 and 1.0%) can be incorporated in the formulation of RTE snacks containing acceptable level of amaranth flour (40% raw), (60% roasted) and amaranth protein concentrate (20%).

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