Development and evaluation of RTE (Ready to Eat) extruded snack using egg albumin powder and cheese powder

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Abstract: Extruded snacks were prepared from flour blends made with corn flour, rice flour and egg albumin powder / Cheese powder in a proportion of 35-50 : 35-50 : 5-30 respectively, and moisture was adjusted to 17-20. Different formulations were extruded at 80 ± 5℃ (heater I) and 75-105℃ (heater II) temperature, 300-350 r m^{-1} screw speed, 100 ± 10℃ die temperature, 3 mm exit diameter of circular die and 15 ± 2 kg h^{-1} feed rate. Sensory acceptability, physical parameters and nutrient analysis along with storage stability of the products was conducted. The protein content of the RTE extruded snack improved by 20% to 50% in experimental samples prepared using egg albumin powder and cheese powder. The physical parameters showed improved expansion ratio compared to control samples with good sensory properties. Storage studies showed increase in moisture content in the extrudates on storage which can be improved using packaging materials with better barrier properties. The use of egg albumin powder / cheese powder in an RTE snack product could make a great contribution to food security in developing countries.

Keywords: Egg albumin powder, Cheese powder, Extrusion, RTE extruded snack

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1 Introduction

In the last ten years, changes in life-style and eating patterns have led to a gradual increase in demand for snack foods. The snack food market is constantly changing relative to product types and although most snacks are not primarily consumed for their nutrients, many snacks are made with nutrition perspective in mind. The snack food industry is experiencing extraordinary changes from the consumer's point of view. Consumers want snacks that taste good and smell good, feel good, look good and in addition, nutritionally superior and healthy.

Extrusion cooking is one of the contemporary food processing technologies applied for preparation of a variety of snacks, specialty and supplementary foods (Harper and Jansen, 1985). Extrusion technology provides the opportunity to process a variety of food products by minute changes in ingredients and processing conditions on the same machine. Several different shapes, texture, color, and appearances can be processed by minor changes in the hardware and processing conditions (Riaz, 2006). Extruded snack category has the greatest potential for growth among the snack foods. The snack can be made to produce innovations that capture the imagination of consumers. Producing a successful snack is a fine balance between consumer's needs like tastes and interests versus manufacturer's production abilities, economics and quality control (Riaz, 2006).

Presently extruded snack products are being made from a variety of ingredients. In general, direct expanded snack is mostly made from corn, wheat, rice, potato, tapioca and oats. For most corn based extruded snacks, dry milled corn meal is used (Enwere, 1998). Rice, as a raw material for extrusion, offers a relatively

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good puffing quality with attractive white color, ease of digestion bland flavor, and is suitable for coating with a variety of flavorings (Moore, 1994; Yagc and Gogus, 2009).

Generally, protein rich food products available in the market are made with vegetable proteins, of which soy protein is the most commonly used. Protein can be obtained from animal or vegetable sources. It is well known that all proteins are not alike. Proteins from different sources have different properties that affect the quality of protein. Egg protein is widely considered as the highest nutritional quality protein of all food sources, providing all the essential amino acids in amounts that closely match human requirements and is therefore a standard against which all other proteins are evaluated (Chernoff, 2004). Eggs in general, and egg white in particular also have very little flavor, and thus do not negatively impact the organoleptic properties of foods, and hence eliminates / reduces the requirements for masking flavors. In spite of these obvious benefits, the prior art does not use egg whites as a major protein ingredient in extruded snacks. Similarly, cheese powder, a good source of protein, is only used as a flavor coating for extruded snacks but has not been used as an ingredient for extrusion.

Extruded snack products are predominantly made from cereal flour or starches and tend to be low in protein and have low biological value (Iqbal et al., 2006). High level of protein combinations with other sources such as egg and cheese powder can provide the basis for a range of highly nutritious extruded snack products (Ozer et al., 2004). Hence, an attempt was made to enhance the taste and nutritive value by incorporating egg albumin powder and cheese powder to develop an RTE extruded snack.

2 Materials and methods

A laboratory model co-rotating twin screw extruder (Scientech Engineers, Calcutta, India) was used for developement of the extrudates. The barrel diameter and L/D ratio were 37 mm and 27:1, respectively with screw configuration standardized for processing flour-based products, was used. This screw profile was made up of conveying self-wiping elements, except for a section consisting of short reverse and forwarding elements, to improve mixing and apply shear to the material being extruded, while restricting flow and building up pressure. The exit diameter of the circular die was 3 mm. A volumetric feeder was used for feeding the dry mixture to the extruder.

Preliminary study: corn flour and rice flour were procured from the local market. De-sugared spray dried hen egg albumin powder, spray dried cheddar cheese powder certified by FDA, GMP, HACCP and ISO, were procured from Venkateswara Hatcheries Pvt. Ltd Pune, Maharastra, India and Indian Dairy Pvt. Ltd New Delhi, India. A preliminary extrusion trial was conducted with different proportions of corn, rice and egg albumin powder (EAP) / Cheese powder (CHP), at a range of extruder conditions, temperature from 80 to 150℃, moisture rate from 17% – 20% and screw rotation from 100 to 400 r m^{-1}). Based on the most stable product, the expansion and stability of the extruder conditions, and the extrusion conditions for the study were selected. Screw speed was set at 300 – 350 r m^{-1}. The input feed rate was set at 15 kg h^{-1}. The cutter (with two blades) speed was set to 100 r m^{-1}.

Detailed study: based on the results of the preliminary study, experimental design and conditions, corn flour, rice flour and EAP / CHP were mixed in a proportion of 35-50 : 35 – 50 : 5 – 30 respectively and moisture was adjusted to 17 – 20 (depending on moisture content of the ingredients) for different formulations. Snack prepared from corn flour and rice flour in ratio of 50: 50 alone served as control.

Preconditioning: to optimize the process variables of extrusion cooking for preparation of the extrudates of maximum possible expansion ratio, with desirable internal and apparent texture, the blended samples were mixed thoroughly to get a homogenous mixture and tempered by adding a predetermined amount of water, by spraying and mixing in a lab model blender thoroughly to adjust the feed moisture content to 17% – 20%. The preconditioned samples were packed in a polythene bag, kept for two hours in a refrigerator at 4℃ for moisture equilibrium and then fed into the extruder hopper.

Different formulations were extruded at 80±5℃

(heater I) and 75 – 105℃ (heater II) temperature, 300-350 r m^{-1} screw speed, 100±10℃ die temperature and 15±2 kg h^{-1} feed rate. The exit diameter of the circular die was 3 mm. Different formulations and process parameters of samples in the trial are given in Table 1.

Table 1 Formulations and process parameters of extruded snacks

Formulations	Proportions	Heater-I Temperature/℃	Heater-II Temperature/℃	Feed rate/kg h^{-1}	Screw speed /r m^{-1}	Die temperature/℃
C.F+R.F	50 : 50	80 ± 5	105 ± 5	15 ± 2	350	100 ± 10
C.F+R.F+EAP /5%	47.5 : 47.5 : 5	75 ± 5	75 ± 5	15 ± 2	300	100 ± 10
C.F+R.F+EAP /10%	45 : 45 : 10	85 ± 5	85 ± 5	15 ± 2	300	100 ± 10
C.F+R.F+EAP /20%	40 : 40 : 20	85 ± 5	90 ± 5	15 ± 2	300	100 ± 10
C.F+R.F+EAP /30%	35 : 35 : 30	85 ± 5	90	15 ± 2	300	100 ± 10
C.F+R.F+CHP /5%	47.5 : 47.5 : 5	75 ± 5	75 ± 5	15 ± 2	300	100 ± 10
C.F+R.F+CHP /10%	45 : 45 :10	75 ± 5	75 ± 5	15 ± 2	300	100 ± 10
C.F+R.F+CHP /15%	42.5 :42.5 :15	75 ± 5	75 ± 5	15 ± 2	300	100 ± 10
C.F+R.F+CHP /20%	40 : 40 : 20	75 ± 5	75 ± 5	15 ± 2	300	100 ± 10
C.F+R.F+CHP /30%	35 : 35 : 30	75 ± 5	75 ± 5	15 ± 2	300	100 ± 10

Note: C.F= corn flour, R.F= rice flour, EAP=egg albumin powder, CHP=cheese powder.

Spicing and drying:the extrudates were sprayed with hot (80℃) refined sunflower oil (70 mL kg^{-1} of extruded snacks) in a rotary tumbler. After thorough mixing of puffs with oil, a standardized spice mix (Piper nigrum, Cuminum cyminum and salt at 2% each) was sprinkled to ensure proper coating on each individual puff. The spiced extrudates were dried for 10 min at 60℃ to have better crispness in final extruded product.

Packaging and storage: the dried products were cooled to room temperature (37℃) and packaged in two different packaging materials i.e High Density Polyethylene (HDPE) with Oxygen Transmission Rate (OTR) of 200 cc m^{-2} d^{-1} and Water Vapor Transmission Rate (WVTR) of 0.5 g m^{-2} d^{-1} and Metalized Polyethylene Terephthalate (MPET) with OTR of 0.95 cc m^{-2} d^{-1} and WVTR of 1.2 g m^{-2} d^{-1} and stored at room temperature i.e., 37℃ ± 4 for 3 months.

Sensory evaluation: the sensory assessments were conducted in a purpose-built, ten-booth sensory evaluation laboratory. The panel of 30 members consisted of staff and graduate students of the Department of Foods and Nutrition, Post Graduate & Research Centre of Acharya N G Ranga Agricultural University. The panelists had no knowledge of the project objectives. All the five samples were coded using random three-digit numbers and served with the order of presentation counter-balanced. Panelists were provided with a glass of water, and instructed to rinse and swallow water between samples. They were given written instructions and asked to evaluate the products for acceptability based on its flavor, texture, color and overall acceptability using five-point hedonic scale (1 = dislike extremely to 5 = like extremely; Meilgaard et al., 1999). The best accepted five products (control along with two from EAP and two from CHP incorporated formulations) among all the formulations were selected for further studies.

Physical parameters: physical parameters like length, diameter, density, expansion ratio of the selected extruded products were recorded. Ten samples each of the different products were taken for measurement and mean of the ten values were recorded.

Length and diameter /mm: length and diameter was of the selected extrudates measured using digital vernier calipers in millimeters (Yamayo, Digimatic Caliper).

Expansion ratio:the radial expansion of the selected extrudates at different portions was measured using vernier calipers and an average of 10 measurements was recorded. The expansion ratio was calculated based on the cross sectional diameter of the extrudate and the extruder die. It is expressed by average of diameter of 10 extrudates divided by diameter of the die used (Singh et al., 2000). (Equation (1))

$$\text{Expansion ratio}=\frac{\text{Diameter of extrudate/mm}}{\text{Diameter of the die/mm}} \tag{1}$$

Bulk density /g mL^{-1}: bulk density was determined by filling a one liter measuring cylinder with the selected extrudates slightly above the liter mark. The cylinder was tapped 12 times till the products measured up to the liter mark. The weight of the extrudates was taken and the bulk density was calculated using the Equation (2)

$$\text{Bulk density}=\frac{\text{Weight/g}}{\text{Volume/mL}} \qquad (2)$$

Proximate analysis:proximate analysis was conducted for the five extruded product formulations. Moisture content of the extrudates was determined using procedure given by Association of Official Analytical Chemists (AOAC, 1990). Energy content was computed from the tables (Gopalan et al. 1991). Protein content was estimated from the crude nitrogen content of the sample determined by the MicroKjeldhal method (N × 6.25) (AOAC, 1990). Fat content of the samples was estimated by Soxhlet method given by American Oil Chemists Society (AOCS, 1981). Carbohydrate was calculated by difference method. Crude fiber content of the samples was determined by the procedure given by Association of Official Analytical Chemists (AOAC, 1990). Total ash was determined using procedure given by Association of Official Analytical Chemists (AOAC, 1984)

Storage studies: the samples stored in different packaging material (HDPE & MPET) were withdrawn periodically (30, 60 and 90th day) and examined for the changes in moisture. The moisture content of the extrudates was determined using procedure given by Association of Official Analytical Chemists (AOAC, 1990).

Statistical analysis: the results were subjected to statistical analysis with the window STAT programme. Mean and standard deviation for three parallel replicates were calculated. Completely Randomized Design (CRD) Analysis of variance (ANOVA) was used to know the significant differences for the different treatment combinations and to find the best treatment combination. The F ratio was also calculated for all the attributes of sensory evaluation and it was compared with F table values to test the significance (Fisher and Yates, 1963).

Results and discussion: extruded snacks were made by incorporating cheese powder / egg albumin powder at different levels by standardizing the process parameters of the extruder.

Sensory evaluation:the mean scores for sensory evaluation of extruded snacks are given in Table 2. All the extrudates scored well for color and appearance. Control sample recorded a higher score for color. As the control sample was prepared with corn (50%) and rice (50%), bright yellow color was seen for control sample whereas experimental extruded snacks were prepared with combinations of corn (35% – 47.5%), rice (35% – 47.5%), cheese and egg albumin powder (5% – 30%) which might have changed the bright yellow color and rendered it to light yellow color.

Table 2 Means score for different sensory attributes of developed products

Treatments	Color & Appearance	Flavour	Texture	Taste	Overall Acceptability
C.F+R.F	4.7 ± 0.37^{b}	3.8 ± 0.30^{a}	4 ± 0.46^{a}	4.5 ± 0.32^{ab}	4.5 ± 0.38^{a}
C.F.+R.F+EAP /5%	4 ± 0.37^{a}	4.1 ± 0.30^{a}	4 ± 0.46^{a}	4 ± 0.32^{a}	4.1 ± 0.38^{a}
C.F+R.F+EAP /10%	3.8 ± 0.37^{a}	4.2 ± 0.30^{a}	4.1 ± 0.46^{a}	3.8 ± 0.32^{a}	4.3 ± 0.38^{a}
C.F+R.F+EAP /20%	5.0 ± 0.37^{b}	3.7 ± 0.30^{a}	3.9 ± 0.46^{a}	3.7 ± 0.32^{a}	4.7 ± 0.38^{ab}
C.F+R.F+EAP /30%	4.7 ± 0.31^{b}	4.0 ± 0.30^{a}	4.9 ± 0.46^{b}	4.8 ± 0.32^{b}	4.9 ± 0.38^{b}
C.F+R.F+CHP /10%	4.1 ± 0.31^{a}	4.2 ± 0.30^{a}	4.5 ± 0.46^{a}	4.2 ± 0.32^{a}	4.2 ± 0.38^{a}
C.F+R.F+CHP /15%	4.1 ± 0.31^{a}	4.8 ± 0.30^{b}	4.2 ± 0.46^{a}	4.9 ± 0.32^{b}	4.8 ± 0.38^{b}
C.F+R.F+CHP /20%	4.0 ± 0.31^{a}	5.0 ± 0.30^{b}	4.3 ± 0.46^{a}	5 ± 0.32^{b}	4.9 ± 0.38^{b}
CD at 5%	0.765	0.609	0.938	0.652	0.774
F ratio	8.3788*	6.6032*	5.877*	7.5256*	8.7949*

Note: Results are mean ± SD of sensory analysis score cards. Means in columns with different letters are significantly different ($p < 0.05$). C.F- Corn flour, R.F-Rice flour, EAP-Egg albumin powder, CHP-Cheese powder, *-significant at 5%).

Limberger et al. (2009) developed cheese flavored snacks which had good sensorial acceptability when compared with broken rice extrudates, in spite of the loss in appearance and color scores when compared to the corn based snacks prepared by the same company. Increasing legume addition affected the various shades of color in the product, for the production of a puffed snack with an enhanced nutrition and spongy structure from a rice-cowpea-groundnut blend at low feed moisture of 14% – 20% and maximum additions of 20% cowpea and 10% groundnut (Emmanuel et al., 2004).

Highest score (5.0) for texture was observed for extrudates made from corn, rice and cheese powder at 20%. Samples prepared by incorporating cheese powder had good textural properties when compared with the extrudates prepared from egg albumin powder. In similar studies conducted by Onwulata et al. (1998); Onwulata et al. (2001), Mladen et al. (2007) and Moreno et al. (2009), whey protein concentrates added at 10% – 25% levels while extrusion had minimal effect on the texture of extruded products. Product quality characteristics were directly related to the whey product content.

Taste of all the extrudates was found to be good. The mean scores ranged from 3.7 – 5.0. The highest acceptability for taste was for the products made by incorporating cheese powder at 20% level. The least acceptability of the taste was seen for products made by incorporating egg powder at 20% level. It was seen that the products made by incorporating cheese powder at different levels received higher scores for taste in comparison to the other experimental. With respect to flavor, all the samples containing cheese were given good scores. The highest scores were given to products which were extruded by incorporating cheese powder when compared with control and extrudates made from egg albumin powder.

Mean overall acceptability scores of the extrudates made by incorporating cheese powder were high. The highest score of overall acceptability was seen for the products made by incorporating CHP at 20% and EAP at 30% followed by CHP at 15% and EAP 20%. The least score for overall acceptability was seen for the products made by incorporating EAP and CHP at 5% and 10% levels. Therefore the formulations made with EAP with 20 and 30%, CHP 15 and 20% along with control were selected for further study. Measurement of physical parameters, nutrient analysis and storage studies were conducted for the selected five samples only.

Measurement of physical parameters: the results of physical parameters are reported in Table 3 which show significant differences (P>0.05) in length and diameter of the extruded products of different formulations. A length of 28.16 to 31.44 mm was observed in EAP incorporated extruded snacks and for CHP incorporated extruded snacks, the length ranged from 39.96 – 45.43 mm.

Table 3 Mean physical parameters of the extruded products

Ingredient	Proportions	Length /mm	Diameter /mm	Bulk density /g mL^{-1}	Expansion Ratio
C.F + R.F	50:50:00	33.02 ± 0.77^{c}	10.8 ± 0.12^{a}	0.059 ± 0.01a	3.36 ± 0.20^{a}
C.F+R.F+EAP (20%)	40:40:20	28.16 ± 0.89^{a}	12.4 ± 0.2^{b}	0.087 ± 0.01b	4.53 ± 0.35^{b}
C.F+R.F+EAP (30%)	35:35:30	31.44 ± 1.17^{b}	10.4 ± 0.32^{a}	0.115 ± 0.002^{c}	3.46 ± 0.55^{a}
C.F+R.F+CHP (15%)	42.5:42.5:15	45.43 ± 0.50^{e}	13.3 ± 0.32^{c}	0.128 ± 0.002^{d}	4.36 ± 0.25^{b}
C.F+R.F+CHP (20%)	40:40:20	39.96 ± 0.83^{d}	14.4 ± 0.26^{d}	0.136 ± 0.001^{e}	4.36 ± 0.1^{b}
C.D. (5%)		1.5697	0.4744	0.0035	0.4697
F ratio		196.3715*	122.3873*	804.9737*	12.2650*

Note: Results are mean ± SD of ten samples analysis. Means in columns with different letters are significantly different (p < 0.05). C.F- corn flour, R.F- rice flour, EAP-egg albumin powder, CHP-cheese powder, *-significant at 5% level.

Among the extruded products made by incorporating CHP at 15% and 20% level, the product with 20% incorporation showed highest diameter (14.4 mm) and expansion ratio. This could be due to good puffing property of cheese. Similar results were found in extruded products made with sweet whey solids which showed increase in diameter upto 25% level but on further increase (50%), diameter of the product was found to decrease (Onwulata et al. 1998; Onwulata et al., 2010).

The product made by using EAP at 20% incorporation level showed better diameter and expansion ratio when compared with 30% incorporation which might be due to good foaming property of EAP that contributed to increase in diameter. A study by Ndife *et al.* (2010) showed that the foaming capacities and stabilities were highest in egg white powder at 97.50% and 78.30% followed by whole egg powder and least in egg yolk powder of 38.5% and 28.08%.

Product made from 30% EAP incorporation showed less diameter because of high protein content. Nelson (2003) and Berrios (2010) reported that increasing the protein levels will lead to decrease in diameter and expansion ratio of the extrudates. In a similar study, the length of extrudates made from sorghum and rice enriched with protein sources ranged from 19.98 to 28.22 mm and diameter ranged from 7.78 to 8.87 mm respectively (Lakshmi Devi *et al*., 2009). According to Onwulata et al. (1998) type and concentration of whey product affects both expansion and breaking strength. Expansion ratio increased with addition of sweet whey solids at 25%, but decreased sharply at 50% level.

Results presented in Table 3 showed significant differences (P>0.05) in bulk density of all the extruded products. Extruded product made from 20% EAP incorporation showed least bulk density (0.087 g mL^{-1}). As bulk density is inversely related to expansion ratio, the corresponding result was evidenced. The extrudates with least bulk density had the maximum expansion ration. A study done by Pracha and Chulaluk (2000) and Pawar (2009) showed decrease in expansion ratio on increase in bulk density in corn based extruded snack.

Analysis of nutrients: the moisture content of all the extrudates varied from 1.8 to 2.44% that is the desired level for extruded snacks in order to maintain the crispness. The energy value of the extrudates ranged from 244.56 to 342.4 kcal $(100\ g)^{-1}$ (Table 4). The products made by incorporating EAP at 30% level showed the lowest energy content while the highest energy content was seen in the control samples. Lakshmi Devi et al. (2009) has reported energy values of 374-386 kcal in extrudates made from sorghum and rice based extruded snacks enriched with protein sources like gram flour, legume mix and defatted soya flour. As the experimental snacks prepared have high protein content, accompanied by a low energy value, these products can be popularized as low calorie high protein foods, functional foods for different age groups and also as supplementary foods for vulnerable age groups.

Table 4 Proximate analysis of the extruded products

Treatment	C.F+R.F	C.F.+R.F+EAP /20%	C.F.+R.F+EAP /30%	C.F+R.F+CHP /15%	C.F+R.F+CHP /20%	C.D /5%	F Ratio
Moisture /g	1.8 ± 0.2^{a}	2.06 ± 0.35^{a}	2.33 ± 0.20^{b}	2.36 ± 0.15^{b}	2.44 ± 0.1^{b}	0.39	4.31*
Energy /kcal	342.4 ± 0.9^{e}	276.6 ± 1.2^{b}	244.56 ± 0.49^{a}	302.9 ± 0.2^{d}	288.0 ± 0.8^{c}	0.47	122.3*
Protein /g	8.36 ± 0.20^{a}	12.36 ± 0.25^{a}	24.46 ± 0.55^{d}	12.53 ± 0.25^{b}	14.36 ± 0.1^{c}	0.46	12.26*
Fat /g	0.73 ± 0.20^{b}	0.43 ± 0.35^{a}	0.66 ± 0.20^{b}	1.94 ± 0.04^{c}	2.28 ± 0.03^{d}	0.27	49.66*
Carbohydrates /g	44.66 ± 3.5^{a}	67.2 ± 0.26^{c}	59.4 ± 0.23^{b}	76.93 ± 0.66^{e}	74.33 ± 1.1^{d}	3.07	177.3*
Fiber /g	0.7 ± 0.24^{a}	1.0 ± 0.2^{a}	0.6 ± 0.23^{a}	0.3 ± 0.29^{a}	1.2 ± 0.21^{a}	1.54	1.64^{NS}
Total Ash /g	0.098 ± 0.003^{d}	0.53 ± 0.003^{c}	0.58 ± 0.001^{b}	1.48 ± 0.01^{a}	1.82 ± 0.005^{a}	0.013	169.6*

Note: Results are mean ± SD of triplicate analysis. Means in columns with different letters are significantly different (p < 0.05). (C.F- Corn flour, R.F-Rice flour, EAP-Egg albumin powder, CHP-Cheese powder, * – Significant, ^{NS} – Non significant).

Protein content varied from 8.36 to 24.46 g. The protein content is the highest in extrudates made by incorporating EAP at 30% level. According to Bangoura and Zhou (2007) extruded sample containing high protein weaning foods were formulated at different ratios using blends of rice, soybean, carrot, whole egg and maltodextrin to achieve the desired level of protein. The extruded products were found to have better nutritional quality as indicated in the high protein content of 17.16, 18.38 and 18.05%, respectively for formulations.

Prasad et al. (2007) reported that extruded snack prepared with sorghum alone had 10.6 g of protein and blend of sorghum with defatted soya increased protein content of extruded snacks to 16.6 g. In the present study experimental samples had higher protein content than control. The increase in protein content could be due to incorporation of concentrated sources of proteins like EAP and CHP.

The fat content of the developed snacks ranged from 0.43 to 2.28 g. Fat content was less for egg incorporated snacks (0.43 and 0.66 g) when compared with control (0.73 g) and cheese based extrudates (1.94 and 2.28 g). Fat content of the experimental extruded snacks showed significant difference at 5% level. Extruded snacks prepared with sorghum and a blend of sorghum and soya flour were reported to have fat content of 2.1 g (Prasad et al., 2007). In the current study, fat content of CHP incorporated snacks was higher, which could be due to higher fat content in cheese powder.

Ash content of the extrudates ranged from 0.09 to 1.8 g. Control extrudates had the least amount of ash content followed by EAP extrudates and CHP extrudates. High amount of ash content was observed in 20% cheese incorporated snack, and this could be attributed to the fact that cheese contains high amount of minerals. The observed increase in ash content could also be due to addition of ripening agents during cheese processing. Similar results were found in study conducted by Chojnowski et al. *(*2006) who reported that addition of citrate and polyphosphate to water-cheese mix considerably increased the ash content in the final sample of the cheese. Results from Table 4 showed significant difference in ash content of the extruded samples (P>0.05). A similar study conducted by Prasad et al. (2007) on sorghum soy based extruded snacks, reported an ash content of about 2.9 %. Extruded snacks prepared from blends of rice brokens and wheat bran showed an ash content ranging from 0.7% – 5.1% (Singh et al., 2010).

Crude fiber content of the extrudates ranged from 0.3 to 1.2 g, not significantly different among the experimental extrudates, which could be due to varied levels of EAP and CHP used in different formulations and extrusion conditions. Kiran, Azeem and Singh (2003) conducted a study on extruded snack foods made with kesari dhal (Lathyrus sativus) and chickpea flour and reported that fibre content ranged from 0.19 – 2.50 g. A similar study conducted by Prasad et al. (2007) on sorghum soy based extruded snacks reported a crude fibre content of about 2.7 %.

The use of egg albumin powder/cheese powder or a combination of both ingredients in an RTE snack product could make a significant contribution to food security in developing countries, as the results of the study showed a considerable improvement in the nutrient content of the RTE extruded snacks developed. A serving of 100 g would contribute 20% – 40% of the RDA for protein, which represents an effective solution for protein deficient diets.

Storage studies: the storage stability of the extruded snacks was evaluated by two analyzing parameters, namely, moisture content of the product and sensory evaluation. The moisture content of the samples stored in different packaging material during the storage period is given in Table 5.

Table 5 Moisture content of the extrudates stored in different packaging material (%) at different storage periods

TREATMENTS	PACKAGING MATERIAL	STORAGE PERIOD			
		ZERO DAY	30th DAY	60th DAYS	90th DAYS
C.F+R.F	HDPE	1.83 ± 0.21^{a}	2.2 ± 0.3^{b}	2.4 ± 0.53^{b}	2.5 ± 0.23^{b}
	MPET	1.83 ± 0.21^{a}	2.0 ± 0.13^{a}	2.1 ± 0.32^{a}	2.1 ± 0.12^{a}
C.F+R.F+EAP /20%	HDPE	2.06 ± 0.35^{b}	2.9 ± 0.42^{g}	3.3 ± 0.42^{g}	3.6 ± 0.21^{g}
	MPET	2.06 ± 0.35^{b}	2.3 ± 0.51^{c}	2.7 ± 0.31^{c}	3.1 ± 0.52^{d}
C.F+R.F+EAP /30%	HDPE	2.33 ± 0.15^{c}	3.0 ± 0.32^{h}	3.4 ± 0.25^{h}	3.8 ± 0.31^{h}
	MPET	2.33 ± 0.15^{c}	2.6 ± 0.46^{e}	2.9 ± 0.62^{d}	3.3 ± 0.24^{e}
C.F+R.F+CHP /15%	HDPE	2.36 ± 0.21^{d}	2.8 ± 0.31^{f}	3.0 ± 0.41^{e}	3.4 ± 0.12^{f}
	MPET	2.36 ± 0.21^{d}	2.5 ± 0.21^{d}	2.7 ± 0.32^{c}	3.1 ± 0.35^{d}
C.F+R.F+CHP /20%	HDPE	2.41 ± 0.12^{e}	2.9 ± 0.35^{g}	3.2 ± 0.42^{f}	3.6 ± 0.52^{g}
	MPET	2.41 ± 0.12^{e}	2.6 ± 0.31^{e}	2.9 ± 0.24^{d}	3.0 ± 0.42^{c}
		T	P	D	T*P*D
CD (5%)		0.016	0.0119	0.011	0.050
F Ratio		2763.311*	527.045*	4629.140*	10.481*

Note: Results are mean ± SD of triplicate analysis. Means in columns with different letters are significantly different (p < 0.05). (T-Treatments, P- Packaging Material, D- Storage period and *-signifcant at 5% level. C.F- Corn flour, R.F-Rice flour, EAP-Egg albumin powder, CHP-Cheese powder).

Results revealed that the initial moisture content of the extrudates ranged from 1.8% to 2.4% was desirable for extruded snacks to maintain the crispness. Samples were withdrawn after every 30 days period for three months and estimated for their moisture content. After 30 days of storage period, the moisture content of the extrudates stored in HDPE increased significantly when compared to MPET. The rise in moisture content of the extrudates stored in HDPE was higher when compared to MPET owing to the better moisture barrier properties of MPET.

After a storage period of two months, the moisture content of the extrudates stored in MPET and HDPE ranged from 2.4 – 3.3 and 2.1% – 2.9 % respectively. After a storage period of three, months the moisture content of the extrudates stored in HDPE and MPET ranged from 2.5 – 3.8 and 2.1% – 3.3% respectively. However, MPET was a better packaging material as compared to HDPE according to the results presented in the study. The results of the present study (Table 5) showed significant difference in moisture content among different packaging material (P>0.05).

During storage, an increase in the moisture content was observed in all the samples irrespective of packaging material. The hygroscopic nature of egg albumin powder and cheese powder could be responsible for the increase in the moisture content during the storage period. The increase in moisture level in the packed product can be controlled by using better packaging material with improved barrier properties to avoid increase in moisture content. Extrudates made from corn and rice (control) became soggy; corn, rice and cheese powder became softer and products prepared from corn, rice and egg albumin powder became tough. Rancidity was observed in both extruded products after 60 days.

A change in flavor was observed in extrudates made from egg albumin powder and cheese powder. Lipid oxidation probably, does not take place during extrusion due to the short residence time for most extrusion processes. However, deterioration in flavor is a concern for extruded snacks during storage (Wang, Klopfenstein and Ponte, 1993). There are several factors that cause rancidity in extruded snacks like initial moisture content of the product and storage conditions etc. However, a combination of good packaging materials with better barrier properties or modified atmospheric packaging can improve the shelf life of the product considerably, by retaining the texture of the products.

3 Conclusion

The results of this study showed that incorporation of egg albumin powder and cheese powder can be effectively used to produce RTE extruded snacks by extrusion cooking. Such ingredients improved the nutrient content of the snacks. The protein content of the RTE extruded snack has increased two-fold on addition of egg albumin powder, and to a considerable extent on addition of cheese powder. It was found that during storage of the products, moisture content increased in the both formulations, which can lead to spoilage. A combination of good packaging materials with better barrier properties or modified atmospheric packaging can improve the keeping quality of the product considerably retaining the texture of the products. The use of ingredients like EAP and CHP in an RTE snack product could make a great contribution to food security in developing countries. A serving of 100 g would contribute 20% – 40% of the RDA for protein, which represents an effective solution to protein deficient diets.

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