International Journal of Research in Engineering and Science (IJRES)
ISSN (Online): 2320-9364, ISSN (Print): 2320-9356
www.ijres.org Volume 4 Issue 6 ǁ June. 2016 ǁ PP. 37-43

A Study on Development of Protein Rich Extruded Puffed Snacks

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ABSTRACT: Extrusion cooking technology is mostly used for cereal and protein processing in the food industry. This technique has been widely used with raw materials such as corn, wheat, rice and, especially in recent years, with soy. In this study we used soy protein isolate which is a good source of protein and contain approx 99% protein. It could be an ideal ingredient for improving the nutritious value of puffed products. The aim of this study was to supplement corn flour and rice flour with various level of soy protein isolate In order to obtain extruded products with good nutritional and textural quality characteristics. Five experimental variants obtained by adding different proportions (0%, 3%, 5%, 7% and 9%) of SPI in corn flour and rice flour mix (40:60 ratio) were used. The result showed a valuable increment in extruded product protein content. The overall acceptability of the soy isolate enriched puffed products was performed by sensory analysis, revealing good organoleptic attributes for the samples upto 9% soy protein isolate.

Keywords: Extrusion, soy protein isolate, puff snacks, sensory attributes

I. INTRODUCTION

Food extrusion is defined as “A process in which material is pushed through an orifice or a die of given shape, the pushing force is applied using a piston or a screw. In food applications, screw extrusion is predominant”. Extrusion cooking is one of the contemporary food processing technologies applied for preparation of a variety of snacks, specialty and supplementary foods [1]. Extrusion processing is one method to produce snack foods. Under high temperature, high pressure conditions it is possible to create a product with a desirable crispy, aerated textural structure. Many benefits are associated with extrusion processing including process versatility, lack of effluent, and high throughput. 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 [2]. Extrusion-technology is gaining increasing popularity in the global agro-food processing industry, particularly in the food and feed sectors. Extrusion cooking technologies are used for cereal and protein processing in food. 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 [3]. Rice, as a raw material for extrusion, offers a relatively good puffing quality with attractive white color, ease of digestion bland flavor, and is suitable for coating with a variety of flavorings [4; 5]. Extrusion alters the nature of many food constituents, including starches and proteins, by changing their physical, chemical and nutritional properties [6]. Cereals and pulses play a predominant role in diets of developing countries, beyond, the nutritional problem is associated with traditional complementary foods, however in the present study, we decided to formulate complementary foods from cereals (rice, maize) and legume. The use of cereal, pulse, and based food has long been advocated as alternative protein and energy source for infant and young children food products. 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. The major ingredients of most snack foods on the market are corn, wheat, rice, potato and oats based. Numerous papers have discussed the role of extrusion technology in the manufacture of wheat and corn products [7] or the role of extrusion technology in altering heat-labile vitamins, minerals or bioactive ingredients (8; 9; 10; 11; 12 and 13].

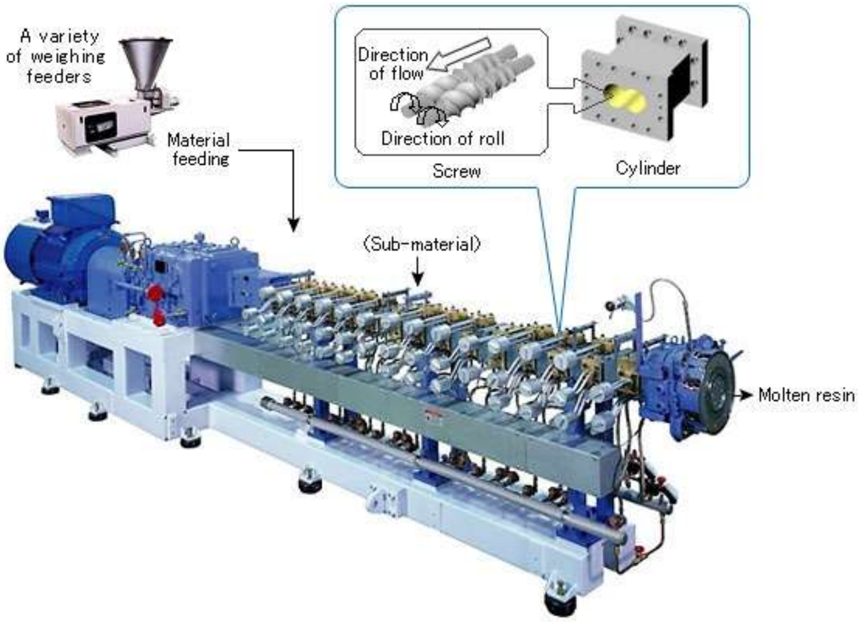

Fig-1 Extruder Machine

Soya protein isolate (SPI) is the most refined form of soya bean proteins, which contains approximately 90% protein on a dry weight basis and is usually prepared from defatted soya bean meal through protein solubilisation at neutral or slightly alkaline pH and precipitation by acidification to the isoelectric region [14]. Generally, consuming food containing soya protein is likely safe, other than some mild side effects (such as allergy, bloating and constipation) which are generally resulted from the specificity of soya protein or inhibitory factors. However, treating by enzymatic hydrolysis or heating could eliminate those drawbacks to a very large extent [15].Soy protein fortification improved the total amount of protein in the final corn four, rice flour and soy protein isolate blend products and making the end product an excellent source of complete protein. For instance, consumption of soy foods may contribute to lower incidences of coronary heart diseases, atherosclerosis, type 2 diabetes, and decreased risk of certain types of carcinogenesis such as breast and prostate cancers as well as better bone health and relief of menopausal symptoms. Animal [16; 17] and human [18; 19]. Extrusion-based strategies can be used to produce novel fortified products from grain flours and other grain materials [20; 21].

II. MATERIALS AND METHODS

Corn flour, rice flour, salt and food color were procured from the local market of Jhansi and the soy protein isolate was received form Dupont, one of largest supplier of soy isolate. For development of the extrudates, BTPL lab model twin screw extruder (Basic technology Pvt. Ltd. Kolkata Model No-002-13-14) was used. An extrusion process was conducted with different proportions of corn flour, rice flour and soy protein isolate. The extruder conditions were, 1st heater temperature 120°C, 2nd heater temperature set on 60°C,the third heater at 140^{0}C. First put moist feed with 25% moisture and optimum extrusion speed 350 rpm. The input feed rate was set at 15 rpm. The cutter (with flour blades) speed was set to 150 rpm.

2.1 Sample Preparation

Based on the results of the preliminary study, experimental design and conditions, corn flour and rice flour were mixed in a proportion of 60-40 and moisture was adjusted to 16%. Snack prepared from corn flour and rice flour in this ratio served as control sample. The soy protein isolate was blended at four different compositions 3%, 5%, 7% and 9%. Similar amount of salt (1.6%) and food color (0.4%) were also added in blends. The blended samples were mixed thoroughly or passed through 10 mesh size sieve twice to get a homogenous mixture and tempered by adding a predetermined amount of water (6%), to adjust the feed moisture content. The preconditioned samples were packed in a polythene bag, kept for 1-2 hour at room temperaturefor moisture equilibrium and then fed into the extruder hopper.

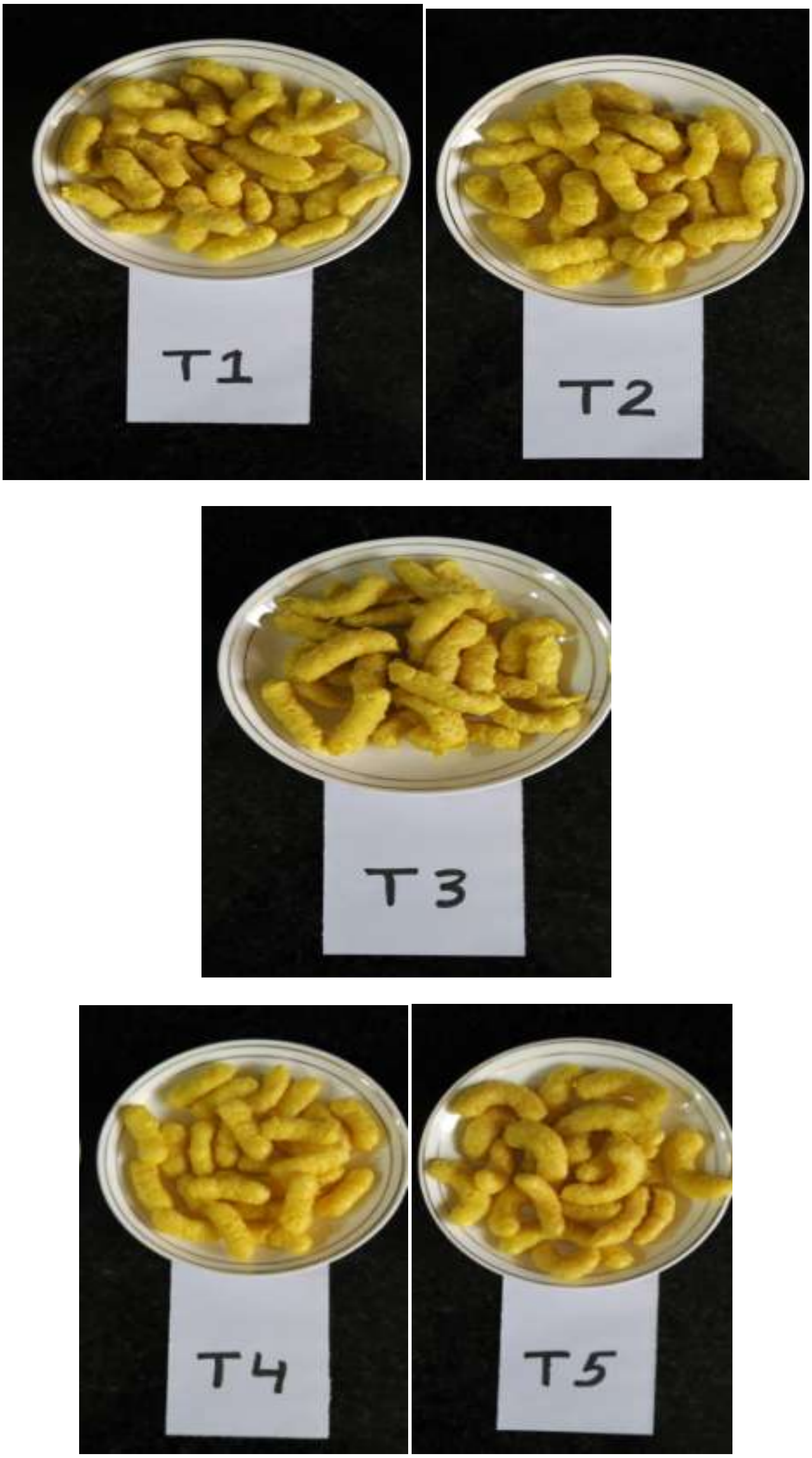

Fig- 3 Extruded puff products

Table- 1. Details of treatments

Ingredient	Control	Blends			
	T1	T2	T3	T4	T5
Corn Flour	150	145.5	142.5	139.5	136.5
Rice Flour	100	97	95	93	91
Soy Protein Isolate	-	7.5	12.5	17.5	22.5
Salt	4	4	4	4	4
Color	1	1	1	1	1
Water	15	15	15	15	15

*Each sample prepared in 250gm

2.2 Texture analysis

Texture was analyzed objectively with a stable Micro- system Texture Analyzer (model TAXT2i). A compression plate was used in conjunction with a texture analyzer [22]. Extrudates were cut at 5 mm distance. Pre-test speed was set to 2 mm/s, a test speed of 2 mm/s, and post-test speed of 5 mm/s. The absolute peak force was considered as the hardness of the puff product. Three samples were used for texture analysis and the results were recorded as an average.

2.3 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 was recorded.

Length and diameter : Length and diameter (in millimeter) of the selected extrudateswas measured by using digital vernier calipers.

Expansion ratio: Expansion ratio (ER) was calculated as the cross sectional area of the extrudates divided by the cross sectional area of the die outlet [23]. The radial expansion of the selected extrudates at different portions was measured using vernier calipers and an average of 10 measurements was recorded.

$$\text{Expansionratio} = \frac{\text{Diameterofextrudate} \quad /\text{mm}}{\text{Diameterofthedie} \quad /\text{mm}} \ldots\ldots\ldots\ldots \ (1)$$

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

$$\text{Bulkdensity} = \frac{\text{Weight } /\text{gm}}{\text{Volume } /\text{ml}} \qquad \ldots\ldots\ldots\ldots \ (2)$$

2.4 Chemical and Statistical analysis

The samples were separately analyzed for proximate composition using the standard methods. Moisture content of flours and the extrudates was determined by I.S.I. 1984. Total ash was determined using procedure given by Association of Official Analytical Chemists method (AOAC, 1984). The extruded puffed products were freshly prepared and organoleptically evaluated by a panel of judges selected from Institute of Food Technology, Bundelkhand University, Jhansi. The products were judged for the quality such as colour, flavour, taste, texture and overallacceptability with the help of 9 point hedonic scale [26]. All statistical analyses were performed using the SPSS version 16.0. For the nutritive composition and physical properties, descriptive statistics (means and standard deviations), and analysis of variance (ANOVA) were used to determine differences among the samples.

III. RESULT AND DISCUSSION

The results of proximate composition analysis of the extruded are presented in Table – 2.

Table-2. Proximate composition of the extruded products

Sample	Moisture	Ash	Protein	Fat	Carbohydrates	Dietary fiber
T1	10.92	3.70	6.45	1.55	77.38	3.75
T2	7.90	2.60	12.86	1.76	74.88	3.64
T3	6.10	2.70	17.13	1.90	72.17	3.56
T4	5.70	2.90	21.40	2.04	67.96	3.49
T5	5.50	3.10	25.67	2.18	63.55	3.41
Mean	7.22	3.00	16.70	1.89	71.19	3.57
SD	2.27	0.44	7.46	0.24	5.52	0.13

SE ±	1.02	0.19	3.36	0.11	2.47	0.59

The incorporation of soy protein isolate (SPI) to produce protein fortified puffed products resulted in higher protein content in extrudates. The protein content increased from 12.86 per cent to 25.67per cent as compared to control sample (6.45 per cent). In the present study experimental samples had higher protein content than control. Similarly, In the current study, protein contents of all the samples were higher, which could be due to high protein content in SPI. The total carbohydrates of the fortified puffed products decreased to 63.55gm as compared to control product (77.38gm). Ash content of the puffed products ranged from 2.6 to 3.7. Control sample had the highest amount of ash content. The least amount of ash content was observed in 3% SPI. However, the incorporation of SPI was showed continuous decrement in moisture and fiber content.

Table- 3. Physical parameters of the extruded products

Sample	**Length**	**Diameter**	**Bulk Density**	**Expansion Ratio**
T 1	35.09±2.39	12.06±0.15	0.0531±0.0007	4.01±0.51
T 2	35.56±0.89	12.29±0.57	0.0521±0.0010	4.09±0.19
T 3	38.73±1.38	12.47±0.75	0.0513±0.0017	4.15±0.25
T 4	34.58±1.21	12.52±0.75	0.0484±0.0008	4.17±0.25
T 5	34.87±2.42	12.80±0.67	0.0468±0.0008	4.26±0.23
F Ratio	9.090*	1.968**	60.546*	1.981**

Results are mean ± SD of ten samples analysis. *The mean difference is significant at the 0.05 (5%) level. ** Non-significant at 5%.

The results of physical parameters are reported in table 3, which show significant differences ($p>0.05$) in length and non-significant differences in diameter of the extruded products of different formulations. A length ranged from 34.58 to 38.73mm was observed in extruded snacks. Among the extruded products made by incorporating SPI at 9% level showed highest diameter (12.80mm) and expansion ratio. Result presented in this table also showed significant difference ($p>0.05$) in bulk density and non-significant difference in expansion ratio of all the extruded products. Extruded products made from 9% SPI incorporation showed least bulk density (0.0468gmL^{-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 ratio. A lower bulk density is generally more desirable considering that it indicates a lighter, crisper final product.

Table- 4. Means score for different sensory attributes of developed products

Sample	**Colour**	**Flavour**	**Texture**	**Taste**	**Overall acceptability**	**Hardness**
T 1	6.60±1.26	6.35±0.88	7.10±0.73	6.40±1.07	6.61±0.82	1173.07±31.02
T 2	7.05±1.16	7.80±0.91	7.75±0.97	7.80±1.47	7.60±0.85	1090.33±4.99
T 3	5.10±1.66	6.10±1.66	6.65±1.70	6.45±1.34	6.17±1.61	976.87±31.39
T 4	8.10±0.99	7.10±1.66	8.05±1.01	7.80±1.31	7.76±0.96	866.0±14.72
T 5	7.25±1.35	7.15±1.73	7.70±1.05	7.40±1.57	7.37±1.15	810.10±47.27
F ratio	**7.130***	**2.282****	**2.436****	**2.615***	**3.702***	**77.27***

Note: Results are mean ± SD of sensory analysis score cards. *The mean difference is significant at the 0.05 (5%) level. ** Non-significant at 5%.

The mean sensory scores for sensory evaluation of extruded products are presented in table 4. All the extrudates products scored well for color and appearance. T4 samples recorded a higher score for color. As this sample was prepared with 7% SPI, bright yellow color was seen for this sample. With respect to flavour, all the samples containing SPI were given good scores. The highest score was given to product which was extruded by incorporating 3% SPI. Whereas 5% SPI containing lowest value. For texture the highest score (7.8) was observed in extrudates made from corn, rice flour and SPI at 3%. Samples prepared by incorporating SPI had good textural properties when compared with the control sample. Taste of all the extrudates was found to be good. The mean scores ranged from 6.4-7.8. The highest acceptability for taste was for the products made by incorporating SPI at 3% and 5% level. The least acceptability of the taste was seen for the control sample. It was seen that the products made by incorporating SPI at different levels received higher scores for taste in comparison to the control sample. Mean overall acceptability scores of the extrudates made by incorporating 7% SPI were high. The least score for overall acceptability was seen for the product made by incorporating SPI at 5% level. When incorporating SPI in corn, rice mixture certain textural attributes decreased as compared to the control sample and the hardness also decreased from 1090.33 to 810.10gm force (Table-4). However, the fortified puffed product was very crispy and still showed considerable expansion and good overall textural characteristics.

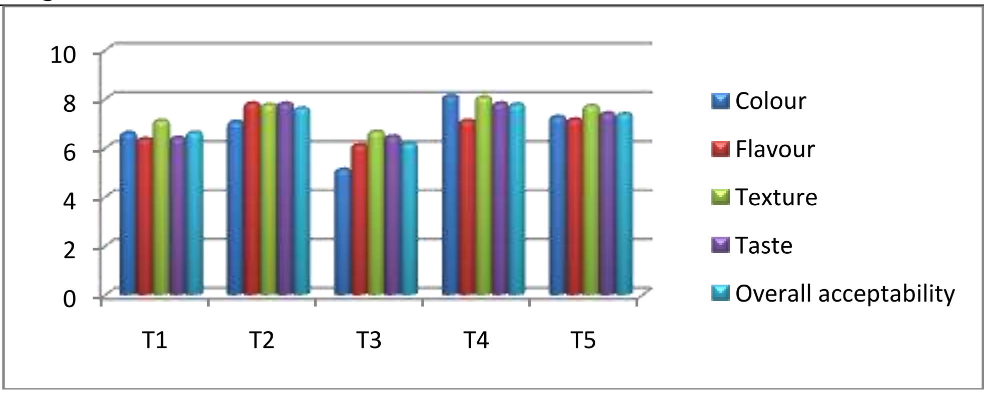

Fig- 2 Response of the treatments on physiological characters of extruded puff products.

IV. CONCLUSION

Now a days consumers want snack that taste good, smell good, feel good, look good and in addition, nutritionally superior and healthy. The demand for non-meat, high protein products is increasing day by day so that we used SPI to enriched puffed product with high protein and the result of this study revealed that the samples contain high protein content, maximum in T5 (25.67) with low moisture. Low moisture extruded products are shelf-stable and extended storage at room temperature. Sensory evaluation also showed that all the products were rated above the average. Color, taste, overall acceptability and hardness showed significant difference whereas flavor and texture showed non-significant difference. In this demonstration extruded product prepared from blesnds of corn flour, rice flour and 7% SPI was found most acceptable for consumers and an excellent source of complete protein and it was also found that expansion ratio and bulk density were improved after SPI incorporation.

V. ACKNOWLEDGEMENT

The above work was undertaken in the Center of Excellence Project funded by Department of Higher Education, Government of Uttar Pradesh, Lucknow. The assistance received under Center of Excellence is duly acknowledged.

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