Intl. J. Food. Ferment. Technol. 6(1): 35-40, June, 2016

DOI: 10.5958/2277-9396.2016.00024.6

RESEARCH PAPER

Effect of Sprouting Treatment on Quality Characteristics of Cereal-Legume Based Extruded Product

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Paper No. 110 Received: 20-7-2015 Accepted: 18-4-2016

Abstract

Wheat grains were sprouted for 24 and 48 h, and cereal-legume flour blend (sprouted wheat flour and defatted soybean flour in the ratio of 80:20) was used to produce extruded product. Effect of addition of sprouted wheat flour on quality characteristics of extruded product showed that the expansion ratio of the extrudates made from sprouted wheat flour for 48 h was significantly ($P<0.05$) higher (3.41) than that of sprouted wheat flour (3.36) for 24 h and sound wheat flour (3.28). However, the bulk density of the extrudates prepared from sound wheat flour was significantly higher (0.18 g/ml) than that of sprouted wheat flour (0.16 and 0.13 g/ml for sprouted wheat for 24 h and 48 h, respectively). Both expansion ratio and bulk density were indicative of the expansion. The extrudates having higher expansion ratio showed lower bulk density and *vice versa*.

Keywords: Bulk density, conditioning, defatted soybean flour, expansion ratio, extrudate, sprouting

Snacks constitutes an important part of many consumers' daily nutrient and caloric intake (Rodriguez-Miranda *et al.* 2010). The most widely consumed snacks include cereal-based products, which generally are low in nutrient density (Da Silva *et al.* 2009). Many snack products are produced using extrusion cooking technology. Incorporation of ingredients with high nutrient density into these snack products could increase their nutritional values. Legume not only holds great promise in meeting the protein needs of poor population, but also contributes to solving some health-related problems of the world population.

Cereals are consumed as staples food worldwide. To produce nutritious products, cereals are usually fortified with lysine or pulse proteins. Legumes are an important source of food protein and other nutrients (Anton *et al.* 2009).

Soybeans are widely recognized by medical and health professionals for their health benefits. These have been found to reduce the risk of coronary heart disease when consumed as a part of a diet low in saturated fat and cholesterol (De Mesa *et al.* 2009). So, blended flour comprised of wheat and soybean can give a product which has a high energy value and proteins with high biological value.

Extrusion cooking is a thermally efficient process and offers many advantages in processing of soy-based products. Extrusion is effective in inactivating lipoxygenase, which is responsible for the formation of beany flavor in a soybean-containing product. Soybean contains anti-nutritional factors like trypsin inhibitors, urease enzyme, which is to be eliminated without degradation of proteins. For this purpose, a high temperature short time process of extrusion is very effective. The low cost autogenous extruders have been found effective for producing nutritious products based on soybean for human food especially for less developed countries (Patil *et al.* 2010).

Sprouting is an inexpensive and effective technology for improving the nutrients availability and diminishing the antinutritional factors in cereals (Yuan *et al.* 2005). The breakdown of seed reserves, carbohydrates and in some cases of proteins take place during germination (Arti and Sukhcharns, 2013).

Full fat soy flour (FFSF) is one of the most promising forms in which soybean protein (40%) and oil (20%) can be used in human diet. But due to rich nutritional value, the soy based foods have poor keeping quality through microbial contaminants and enzymes like lipoxidase/protease. The oxidative rancidity may also develop due to non-enzymic decomposition of lipid hydroperoxide. Under Indian climatic conditions, wherein some parts such environment prevails, storage stability of FFSF becomes a problem, therefore, the byproduct of soybean oil industries that is defatted soy flour (DFSF), was used in various value added products to increase storage stability and reduce the cost of product (Bargale and Griffin, 2011). The objective of this study was to decide the suitable blend of sprouted wheat flour and defatted soy flour for better quality of the product. The quality of the extrudates was evaluated for physico-chemical, sensory and functional properties.

Materials and Methods

In this investigation, the basic raw materials such as wheat and defatted soy flour were procured from Central Institute of Agricultural Engineering (CIAE), Bhopal for the preparation of extruded products at that institute by using single screw Wenger X-5 extruder. Other materials such as salt and sugar were purchased from the local market. The work on process optimization, determination of colour and hardness of extruded products was carried out in CIAE, Bhopal and the analytical work was carried out at Department of Food Science and Technology, College of Food Technology, Marathwada Krishi Vidyapeeth, Parbhani.

Preparation of sprouted feed for extrusion

Sprouting of wheat was carried out in the laboratory for 24 and 48 h, as described by Singh *et al.* (1987). The samples were milled in a mill after proper conditioning and were kept in air-tight containers for use in extrusion experiments. The moisture content of the blend of wheat flour: DFS at 80:20 ratio was adjusted to optimum moisture content (15% wb) by spraying required amount of distilled water and mixing continuously.

Preparation of extruded product by using Wenger X-5 extruder

Wenger X-5 laboratory single screw extruder consisted of extrusion single screw with die and motor operated feeder and a sample cutter. It was equipped with a 5 HP variable speed motor capable of rotating the extruder screw between 100 to 500 rpm. The accessories required for its operation were a boiler for generating steam and water pump aided with a compressor for increased water pressure during supply. The water and steam could be circulated singly or in combination through jacketed heads and barrel temperature profile was maintained. The motorized feeder could be calibrated for its feed rate at different knob positions for various kinds of food mixes for extrusion.

Preparation of feed blends for extrusion

Different blends of sprouted wheat flour and defatted soy flour (80 mesh) were prepared in the proportion of 100:0, 90:10, 80:20, 70:30 and 60:40.

Extrusion of samples

The boiler was kept ready for supply of steam at a pressure of 15 kg/cm^2. The air pressure was maintained at 7.5 kg/cm^2. Then, water was circulated through all the heads. The water supply was stopped in sequence starting from the head nearest to the extruder die followed by next head towards the feed end of the extruder.

In same sequences, the supply of steam was started simultaneously. Switched on the extruder motor, when the two heads near to the extruder end were sufficiently hot, started with an initial speed of 100 rpm for screw. Af erwards, opened the feeder opening, enabling feeding and flow of material in the extruder. When the product appeared at the die, the feed rate was increased and water rate was gradually reduced. Initially, material came out in the form of paste followed by its shaping into continuous rope. Operating parameters were changed until desired texture and puffing were achieved. The temperature was measured at the die using automatic temperature recorder.

The blends of raw materials were extruded at a feed rate of 40kg/h, using Wenger X-5 extruder with screw speed of 450 rpm, die diameter of 3.44 mm and temperature at the die 100^{o}C as described by Sing *et al.* (2006a, 2006b). Af er having optimized the proportion of wheat flour and defat ed soy flour on the basis of physical, nutritional and sensory at ributes of extruded product the most suitable combination of 80:20 was chosen for optimization of extruder operating conditions using Sensory evaluation. Then, the cylindrical rods obtained from the extruder were dried in a tray drier at 60±2^{0}C for about 3 hours to obtain dry extrudate rods (7-8% moisture) as per the method described by Bhat acharya and Prakash (2004).

Analysis

The samples were analysed for chemical composition as per the standard methods (AOAC, 1980) while sensory evaluation was performed by the prescribed methods (Joshi, 2006).

Results and Discussion

Chemical composition of sprouted wheat flour and defat ed soy flour

Chemical composition of sprouted wheat flour and defat ed soy flour presented in Table 1 indicates that defat ed soy flour contained more proteins (50%) than wheat flour (11.9%) whereas the carbohydrate content of wheat flour was more (71.2%) than that of defat ed soy flour (30%) which has major role to play in the quality characteristics of extruded products.

Table 1: Chemical composition of sprouted wheat flour and defatted soy flour

Constituents, %	Wheat flour	Defat ed soy flour
Moisture	12.50±0.011	10.00±0.009
Proteins	11.90±0.010	50.00±0.009
Carbohydrates	71.20±0.006	30.00±0.009
Fat	1.62±0.012	1.20±0.006
Ash	1.63±0.007	5.00±0.012
Crude fiber	1.26±0.007	3.80±0.010

The fat, ash and crude fiber contents of wheat and defat ed soy flour were found to be 1.62, 1.63, 1.26 and 1.2, 5.0, 3.8%, respectively. Similar results have been reported by Dupont *et al.* (2006) and Sramkova *et al.* (2009) for various wheat flours and Masur *et al.* (2009) and Anonymous (2010) for defat ed soy flours.

Proximate composition of raw blends and extruded products

Proximate composition of raw blends and extruded products is presented in Table 2. These values showed that the moisture content of the extruded products ranged from 6.2 to 6.3%. There was no significant difference ($p > 0.05$) in the moisture content of the extrudates of all the blends. This might be at ributed to the fact that all materials were conditioned to the same moisture content i.e. 15% (wb) before extrusion cooking which might have resulted into a non-significant change in the moisture content of all the extruded products.

Table 2: Proximate composition of raw blends and extruded products (g/100g)

Blends	Moisture, %		Protein, %		Fat, %		Minerals/ash, %		Crude fiber, %		Carbohydrate, %	
	Raw	Extruded	Raw	Extruded	Raw	Extruded	Raw	Extruded	Raw	Extruded	Raw	Extruded
100:0	12.25	6.2	11.96	12.11	1.62	1.51	1.63	1.74	1.26	1.34	71.20	67.83
90:10	12.25	6.3	15.71	15.91	1.56	1.46	1.94	2.04	1.46	1.54	67.08	63.05
80:20	12.00	6.2	19.52	19.82	1.52	1.42	2.28	2.37	1.72	1.78	62.96	57.35
70:30	11.75	6.3	23.33	23.53	1.48	1.49	2.62	2.71	1.98	2.06	58.84	54.36
60:40	11.50	6.2	27.14	27.44	1.44	1.45	2.96	3.05	2.24	2.29	54.72	51.27
SE±	0.018	0.059	0.005	0.005	0.005	0.005	0.008	0.006	0.005	0.005	0.006	0.006
CD at 5%	0.059	NS	0.016	0.016	0.016	0.016	0.025	0.021	0.0187	0.016	0.021	0.021

Blends = Wheat flour: Defatted soy flour

The inclusion of defatted soy flour at 10, 20, 30 and 40% in wheat flour significantly increased the protein, minerals and crude fiber contents of the products. The protein content of blend was 11.96 to 27.14% and that of the extruded products ranged from 12.11 to 27.44%.

Inclusion of defatted soy flour in wheat based products apparently increased the protein content. The reason for increase in protein content in blends at different proportions is obvious i.e. about 5 times more protein in defatted soy flour than wheat flours. Moreover mild heat treatment of vegetable proteins generally improves protein content due to inactivation of protease inhibitors and other antinutritional substances. Less changes in the nutritional value of proteins of cereal based blends after processing in single screw extruders has been reported by Harper and Jansen (1981).

Physical and sensory properties of extruded products of different blends

The physical and sensory properties of extruded products of different blends presented in Table 3 indicate that expansion ratio of extruded products varied widely among the samples. Extrudates from wheat alone (100:0) and the wheat : DFS blend (60:40) showed expansion ratio of 2.85 and 2.59 respectively, whereas wheat : DFS blend in the ratio of 80:20 gave highest expansion ratio of 3.28. Wheat flour fortified with 20% DFS produced extrudates with high expansion as compared to wheat flour alone and all other blends. Similar results have been obtained by Anton *et al.* (2009) for corn and corn-bean flour extrudates.

Effect of sprouting on quality characteristics of extruded product

The data on the effect of addition of sprouted wheat

Table 3: Physical and sensory properties of extruded products of different blends

Blends	Expansion ratio	Bulk density g/ml	Sensory Score			Colour		
			Crispiness	Taste	Overall acceptability	Whiteness L	Redness A	Yellowness B
100:0	2.85	0.23	7.0	7.0	7.0	73.77	2.91	16.73
90:10	3.12	0.19	8.0	8.0	8.0	71.77	2.67	17.66
80:20	3.28	0.18	9.0	9.0	9.0	68.49	2.45	18.99
70:30	2.88	0.37	8.0	7.0	8.0	66.02	2.18	19.12
60:40	2.59	0.39	8.0	8.0	7.0	64.99	2.05	20.28
SE ±	0.007	0.008	0.537	0.577	0.527	0.009	0.005	0.005
CD at 5 %	0.022	0.036	1.69	1.81	1.658	0.030	0.018	0.018

flour on quality characteristics of extruded product presented in Table 4 shows that the expansion ratio of the extrudates made from sprouted wheat flour for 48 h was significantly (P<0.05) higher (3.41) than that of sprouted wheat flour (3.36) for 24 h and sound wheat flour (3.28). However, the bulk density of the extrudates prepared from sound wheat flour was significantly higher than that of sprouted wheat flour. The bulk density of extrudates prepared from sound wheat flour was 0.18 g/ml and that of sprouted wheat for 24 h and 48 h was 0.16 and 0.13 g/ml, respectively. Both expansion ratio and bulk density were indicative of the expansion. The extrudates having higher expansion ratio showed lower bulk density and *vice versa*.

Table 4: Effect of sprouting on quality characteristics of extruded product

Wheat type	Expansion ratio	Bulk density (g/ml)	Specific energy (wh/kg)	Sensory Score	
				Texture	Overall acceptability
Sound	3.28	0.18	240	4.5	6.0
24 h sprouted	3.36	0.16	200	5.5	6.5
48 h sprouted	3.41	0.15	180	6.0	7.0
SE ±	0.034	0.017	10.00	0.408	0.408
CD at 5%	0.04	0.01	34.55	0.40	0.40

The specific energy requirements of extruder was the highest for extrusion cooking of flour from sound grains (240 wh/kg) and lowest for flour from 48 h sprouted wheat (180 wh/kg). The decrease in specific energy requirements in flour from sprouted wheat might be due to breakdown of gluten proteins during sprouting and their lower viscosity in the psedoplastic melt within the extruder. The lower viscosity of flour from sprouted wheat flour of the psedoplastic melt within the extruder caused by higher temperature and decreased protein content reduces power consumption of extruder may be contributed to lower specific energy. Similar results have been reported by Sekhon *et al.* (1992) for sprout damaged wheat.

Conclusion

It is concluded that, a good quality extrudate from a blend of sprouted wheat flour and defat ed soybean flour in the ratio of 80:20 can be prepared with bet er physico-chemical, sensory, functional, nutritional characteristics, hence this technology of extrusion cooking at laboratory scale can be exploited on industrial scale. Effect of addition of sprouted wheat flour on quality characteristics of extruded product shows that the expansion ratio of the extrudates made from sprouted wheat flour for 48 h was significantly (P<0.05) higher (3.41) than that of sprouted wheat flour (3.36) for 24 h and sound wheat flour (3.28).

Further, both the expansion ratio and bulk density were indicative of the expansion.

References

A.O.A.C. 1980. Official Methods of Analysis. 11th edn. Washington, D.C. Association of official Analytic chemists.

Anonymous. 2010. Composition of foods: Legume and legume products. USDA, Human Nutrition Information Service Hand Book No. 8-16.

Anton, A.A., Fulcher, R.G. and Arntfield, S.D. 2009. Physical and nutritional impact of fortification of corn starch-based extruded snacks with common bean (*Phaseolus vulgaris* L.) flour: Effects of bean addition and extrusion cooking. *Food Chem*, **113**: 989-996.

Arti Chauhan and Sukhcharns Singh, 2013. Influence of germination on physico- chemical propertiesvof Amaranth flour. *International Journal of Agriculture and Food Science Technology,* **4**(3): 215-220.

Bargale, P.C. and Griffin, R.C. 2011. Studies on modified atmospheric packaging of full fat soy flour. *Ind J Nutr Dietet*, 28: 118-121.

Bhat acharya, S. and Prakash, M. 2004. Extrusion of blends of rice and chick pea flours: A response surface analysis. *J Food Engg*, **21**: 315-330.

Da Silva, M.C., De Carvalho, C.W.P. and Andrade, C.T. 2009. The effects of water and sucrose contents on the physicochemical properties of non-directly expanded rice flour extrudates. *Cienc Tecnol Aliment*, **29**: 3.

De Mesa, N.J.E., Alavi, S., Singh, N., Yong-Cheng, S., Dogan, H. and Sang, Y. 2009. Soy protein-fortified expanded extrudates: Baseline study using normal corn starch. *J Food Engg*, **90**: 262-270.

Dupont, F.M., Hurkman, W.J., Vensel, W.H., Tanaka, C., Kothari, M.K., Chung, O.K. and Altenbach, S.B. 2006.

Protein accumulation and composition in wheat grains: Effects of mineral nutrients and high temperature. *European J Agro*. **25**: 96-107.

FAO/WHO/UNO 2005. Energy and protein requirements. Report of a joint expert consultation. Technical Report Series No. 724. Geneva, Switzerland.

Harper, J.M. and Jansen, G.R. 1981. Nutritious foods produced by low cost technology. LEC Report 10 Colorado State University Fort Collins Colorado.

Joshi, V.K 2006. Sensory Science: Principles and Application in Food Evaluation. Agrotech publishing Academy, Jaipur, pp. 536.

Leblabc, M.J., Gavino, V., Perea, A., Yousef, I.M., Levy, E. and Tuchweber, B. 1998. The role of dietary choline in the beneficial effects of lecithin on the secretion of biliary lipids in rats. *Biochimica-et-Biophysica-Acta.* **1393**: 223.

Li, S.Q. and Zhang, Q.H. 2001. Advances in the development of functional foods from buck wheat. *Crit Rev Food Sci Nutr.* **41**: 451-464.

Masur, S.B., Tarachand, K. and Kulkarni, U. 2009. Comparative evaluation of full and defat ed soy flour based bakery products. *Karnataka J Agri Sci.* **22**: 937-938.

Patil, R.T., Singh, D.S. and Tribelhorn R.E. 2010. Effect of processing conditions on extrusion cooking of soy-rice blend with a dry extrusion cooker. *J Food Sci Technol.* **27**: 376-378.

Rodríguez-Miranda, J., Ruiz-López, I.I. and Herman-Lara, E., Martínez-Sánchez, C.E., Delgado-Licon, E. and Vivar-Vera, M.A. 2010. Development of extruded snacks using taro (*Colocasia esculenta*) and nixtamalized maize (*Zea mays*) flour blends. Lebensm-Wiss Technol Available Online 8 July 2010.

Sekhon, K.S., Singh, N. and Nagi, H.P.S. 1992. Effect of pearling and blending on the bread making properties of sprout damaged wheat. *Cereal Food World*, **37**: 715-716, 721-724.

Singh, D.S., Garg, S.K., Singh, M. and Goyal, N. 2006a. Optimization of processing parameters of extrudate prepared from Bengal gram broken and sorghum blends by using Wenger X - 5 extruder. *J Food Sci Technol.* **43**: 301-304.

Singh, D.S., Garg, S.K., Singh, M. and Goyal, N. 2006b. Effect of major processing parameters on the quality of extrudates made out of soy-kodo blends. *J Food Sci Technol.* **43**: 434-437.

Singh, N., Sekhon, K.S. and Nagi, H.P.S. 1987. Laboratory sprouting damage and effect of heat treatment on milling and baking properties of Indian Wheat. *J Food Sci*, **52**: 176-179.

Sramkova, Z., Gregova, E. and Sturdik, E. 2009. Chemical composition and nutritional quality of wheat grain. *Acta Clunica Slovaca.* **2**: 115-138.

Yuan Zhu, Ju Fang Dong and Mao Jun Xu. 2005. Effect of germination condition on ascorbic acid level and yield of soybean sprouts. *J. Sci. Food Agric,* **85**: 943 – 947.