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Shelf Life Challenges: Investigating the Effects of Storage Conditions on Deoiled Rice Bran-Enriched Extruded Products

Deep Shikha[1], Anmol Dhillon[1], Sarvika Awasthi[1]
[1]Department of Food Technology, Bhai Gurdas Institute of Engineering and Technology, Sangrur

Abstract: The purpose of this study was to develop extruded snack product using optimized formulation of rice flour, corn flour and deoiled rice bran. The properties like lateral expansion (LE), bulk density (BD), water absorption index (WAI), water solubility index (WSI) and hardness of the optimized extruded product were investigated. The storage studies of quality extruded product showed greater changes to moisture content and hardness packed in low density polythene in comparison to aluminium laminated pouches kept under ambient and accelerated conditions. Higher variation in quality parameters was observed at accelerated storage condition. Therefore, it was suggested that aluminium laminated packaging materials can store extruded product for a longer time period than low density polythene packs in both storage conditions.

Keywords: Packaging Materials, Hardness, Quality parameters.

Research Paper

***Corresponding Author:**
Deep Shikha
Department of Food Technology, Bhai Gurdas Institute of Engineering and Technology, Sangrur

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INTRODUCTION

Deoiled rice bran, a co-product of rice milling and rice bran oil extraction, has gained a great momentum because of its nutritional composition. It is a rich source of proteins, carbohydrates (mainly starch), dietary fibers and vitamin E enriched micronutrients such as tocopherols, tocotrienols, oryzanols and phytosterols, minerals (Mg, K, Fe and Mn), B-vitamins, and an excellent source of choline and inositol (Hoffpauer et al., 2005) and possesses several health benefits, is put in no use and treated as a waste material. Keeping in view, the benefits and nutritional importance of deoiled rice bran, investigations had been carried out to prepare a health promising ready-to-eat extruded snack.

Now-a-days, an increased amount of attention is paid towards the development of value added foods that promote well-being and improved health. The improvement and retention of nutritional value of food during processing has remained one of the most challenging tasks. The demand of making novel food products with health benefits and minimum loss of nutritive value can be achieved by the latest and most important cooking process, that is extrusion cooking. The extrusion allows the destruction of antinutritional factors, gelatinization of starch, increased soluble dietary fiber and reduction of lipid oxidation during food processing (Frame, 1994; Harper, 1981; Smith and Singh, 1996).

Although extrusion is a short time cooking practice, the temperatures that come in contact with raw material in the extruder barrel are sufficient to cause variation in the major and non-nutritive factors (Singh et al., 2007). The major changes brought in the starch and protein components of raw material are responsible to form final structure and to provide texture and bulk density. The other beneficial components like polyphenols, having antioxidant properties may undergo various changes, thus altering the antioxidant activity of final product. So, by keeping in mind the consumer interest towards healthy, natural and organic food as well as rising scope of snack foods in global markets, the rice industry waste was utilized in the form of functional food ingredients for human consumption. The main objectives of present research work were to evaluate the different properties of optimized extruded product as well as to determine the quality changes taking place in quality parameters of extruded snack product during ambient and accelerated storage conditions.

MATERIAL AND METHODS

The raw materials used for the development of nutritionally enriched snack product (rice flour, corn flour) were procured from local market of Sangrur (Punjab, India) and deoiled rice bran was obtained from A. P. Solvex, Dhuri (Punjab, India).

Extrusion

Extrusion was done using twin-screw extruder of co-rotating type (G.L. Extrusion Systems Pvt. Ltd., Delhi) having barrel with electric band heaters, water cooling jackets, temperature sensor fixed on front die, 7.5 HP motor (400 V, 3ph, 50 cycles), automatic cutter fixed on rotating shaft was used. Ingredient formulation was chosen on the basis of previous studies using response surface methodology (17.73% deoiled rice bran, 10% corn flour and 72.27% rice flour). Extruder was kept running before extrusion process to stabilize the adjusted temperature 124±1°C and screw speed of 295±1 rpm. The moisture content of raw flours was adjusted to 13.94% to obtain the extruded snack product based on optimization (Sharma et al., 2017). The prepared samples were stored at room temperature in polyethylene pouches for 24h (Stojceska et al., 2008). After the conditioning of samples, these were then fed into feed hopper at a feed rate of 4kg/h. The die diameter of 4mm was selected. The product was collected at the die end and stored in already labeled zipped pouches for further characterization.

Characterization of Extruded Product

Lateral expansion (LE)

Lateral expansion (LE) is the extent of puffing exhibited by the product when it exists the extruder die. It is measured by using vernier caliper according to the methods given by Meng et al. (2010). Lateral expansion (%) was calculated by using following formula:

$$\text{LE (\%)} = \frac{(\text{diamter of extrudate} - \text{diameter of die hole})}{\text{diameter of die hole}} \text{ X } 100$$

Bulk density (BD)

The bulk density (BD) of the extruded product was measured by literature method of Stojceska et al. (2008). It was determined according to following formula:

$$\text{BD (g/cm}^3) = \frac{4\text{m}}{\pi \text{d}^2 \text{L}}$$

In the above formula, m is the mass (g) and L is the length (cm) of extrudate with diameter d (cm).

Water absorption index (WAI) and Water solubility index (WSI)

Water absorption index (WAI) and Water solubility index (WSI) were measured by standard methods (Anderson et al., 1969; Yağcı and Göğüş, 2008; Stojceska et al., 2008). The fine powdered extrudate sample was suspended in water at room temperature for 30 minutes along with continuous stirring and then centrifuged at 3000 rpm using centrifuge machine (Remi laboratory instruments) for a time period of 15 minutes. The supernatant liquid was decanted into a known weight of evaporating dish. The WAI was calculated as the weight gain by gel after the decantation of supernatant liquid to the weight of original dry extrudate. The water solubility index (WSI) was determined as the ratio of the weight of dry solid obtained in supernatant liquid to the original weight of sample. The following formula was used to calculate water absorption and water solubility properties of the extrudates.

$$\text{WAI (g/g)} = \frac{\text{Weight gain by gel}}{\text{Dry weight of extrudate}}$$

$$\text{WSI (\%)} = \frac{\text{Weight of dry solid in supernatent}}{\text{Dry weight of extrudate}} \text{ X } 100$$

Hardness

The hardness of the extrudate was determined using a TA-XT2 texture analyzer with 500 kg load cell (Stable Micro Systems Ltd., Godalming, UK). About 40-45 mm long extruded puff product was compressed with a probe SMS-P/75 mm diameter at a crosshead speed 5 mm/s to 3 mm of the extrudate. The compression generates a graph between force and distance. The maximum value of force in the highest peak was taken as hardness because it indicates the initial rupture of snack at one point (Stojceska et al., 2008). About five randomly collected samples of each experimental run were compressed for measurement of hardness and average was taken as hardness.

Storage Studies

The extrudates (50 g) prepared under the optimized conditions were packed in two types of packaging materials in low density polyethylene (LDPE) and aluminum laminated polythene (ALP). Both packets were sealed carefully using polythene sealing machine. The sealed sample pouches were then kept under ambient (51±1%, RH and 30±1 °C, temperature) and accelerated (90±1% RH, 40±1 °C, temperature) storage conditions. Stored samples were analyzed for moisture content and hardness at every 15 days interval for 75 days.

RESULTS AND DISCUSSIONS

Characterization of Extruded Product

The quality of any extruded product is described by the degree of puffing. Higher expansion is one of the desirable feature for the extruded food product and is highly affected by moisture content of the feed ingredients, screw speed, die temperature and feed rate (Ali *et al.*, 1996; Seth *et al.*, 2015). In the present study, expansion was observed to be 168.28%. Bulk Density (BD) is another major physical property of the extruded products. It was found to be 0.271 g/cm.

Water absorption index denotes the quantity of water absorbed by starch when it is dispersed in excess water. The ability of starch to absorb water may be related to gelatinization process as raw starch does not absorb water. It is the gelatinized starch, which absorb water. The extent of water absorption is significantly influenced by moisture content of feed and temperature of extrusion process (Ding *et al.*, 2005).

Water solubility index (WSI) denotes the amount of dry material recovered after the evaporation of supernatant liquid obtained from the measurements of water absorption index. The optimized extruded product was found to have water absorption index of 5.95 g/g and water solubility index of 12.94 %.

Textural measurement of extruded products is considered to be the most important characteristic properties and strongly associated to the user acceptance. The hardness is associated with degree of puffing and was found to be 12.43 N.

Storage Study

The packaging material and storage conditions were found to have great impact on the different physical and sensory characteristics of extruded snack product. The samples were analysed at regular interval of time during storage. The samples contained in two types of packaging material were analyzed for a time period of 75 days kept at ambient and accelerated storage conditions. The extruded snack packed in low density polythene packs showed greater changes to quality parameters in comparison to aluminium laminated pouches under both conditions.

Moisture content (%)

The moisture content of extruded product contained in sealed LDPE and ALP kept under ambient and accelerated storage conditions was found to be amplified as shown in Table 1. The increase in moisture content of the extruded sample was ranged from 6.48% to 9.65% in LDPE and 6.48% to 8.83% in ALP during ambient storage. While the gain of moisture content in both packets for a time period of 75 days was 6.48% to 10.75% and 6.45% to 9.87% in case of accelerated storage conditions. The rise in moisture content may be due to movement of water vapor through the packaging material from the storage environment. It was also observed that the increase in moisture content was more for the extruded sample packed in LDPE as compared to sample packed in ALP in both storage conditions. This may be due to the more permeability of LDPE to water vapours in comparison to the aluminium foil laminated polythene.

Table 1 Moisture content of extruded snacks packed in LDPE and ALP at ambient and accelerated storage conditions

Moisture content (%)				
Storage Time	**Ambient conditions**		**Accelerated conditions**	
	LDPE	ALP	LDPE	ALP
0	6.48	6.48	6.48	6.48
15	7.15	6.82	7.75	7.31
30	7.75	7.22	8.55	7.98
45	8.51	7.63	8.98	8.35
60	9.21	8.23	9.87	9.31
75	9.65	8.83	10.75	9.87

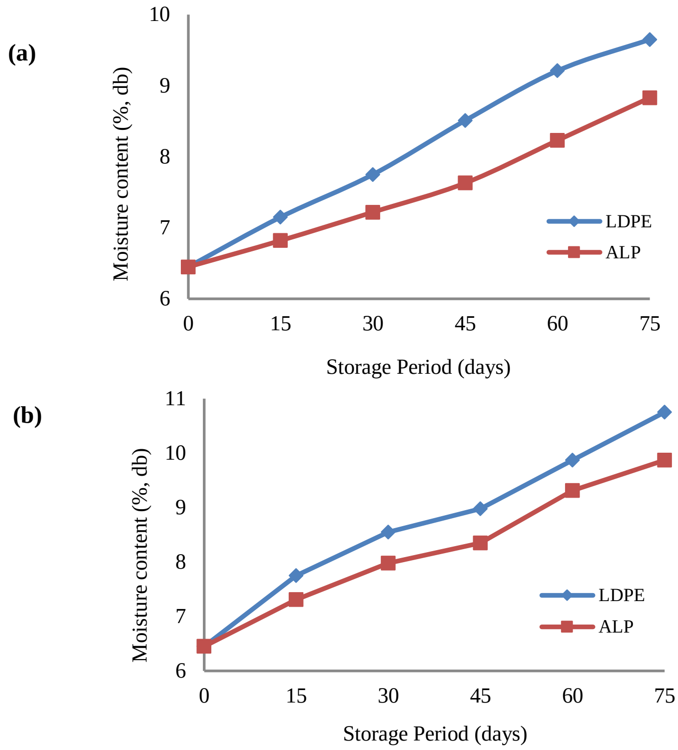

Figure 1: Effect of packaging materials on moisture content of extruded product at (a) ambient storage conditions (b) accelerated storage conditions

Further, the moisture uptake was at slower rate at atmospheric storage condition in comparison to the accelerated storage condition because of high temperature and relative humidity. Hence, the moisture uptake by extruded product during storage depends upon the type of packaging material as well as on the storage conditions. The variation of moisture content in both packets under ambient and accelerated storage conditions for a time period of 75 days is shown in Fig.

Hardness (%)

Hardness is an important textural property of extruded product which describes the quality and acceptance of the food product by the consumer. During the period of storage studies, the hardness of snack product varies from 10.80 N to 16.18 and 10.80 to 15.26 in LDPE and ALP respectively in ambient storage conditions and it was found to be in the range of 10.80 to 17.42 N and 10.80 to 16.61 N for LDPE and ALP packed extrudates under accelerated storage conditions. An increase in hardness of the extruded product with storage days was observed as shown in Table 2.

Table 2: Hardness of extruded snacks packed in LDPE and ALP at ambient and accelerated storage conditions

Hardness (N)				
Storage Time	**Ambient conditions**		**Accelerated conditions**	
	LDPE	ALP	LDPE	ALP
0	10.80	10.80	10.80	10.80
15	12.43	12.48	12.76	12.51
30	13.32	12.92	14.27	13.35
45	14.88	13.46	15.32	14.12
60	15.35	14.17	15.96	14.92
75	16.18	15.26	17.42	16.61

The hardness of extrudates packed in LDPE pouches increases more in comparison to extrudates packed in ALP for both storage conditions. The effect of storage conditions on hardness of snack product is shown in Fig. 2. The higher hardness was observed for the snack product kept under accelerated conditions than ambient storage conditions. This may be directly correlated with moisture content during storage period. The increase in hardness of extrudates with storage period was also reported by Smithey et al., (1995).

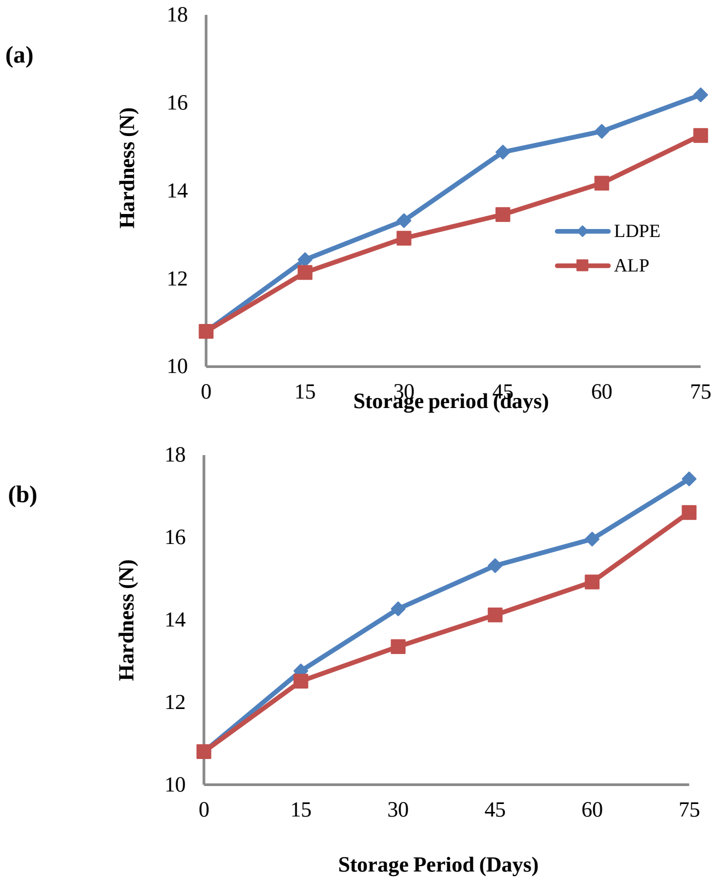

Figure 2: Effect of packaging materials on hardness of extruded product at (a) ambient storage conditions (b) accelerated storage conditions

CONCLUSION

In the present work, the physio-chemical properties (LE, BD, WAI, WSI and hardness) of the deoiled rice bran extruded product were studied. The extruded product was found to have lateral expansion of 168.28%, bulk density, 0.271 g/cm^3; water absorption index, 5.95 g/g; water solubility index, 12.94 %; Hardness, 12.43 N.

A significant impact of packaging material, temperature and humidity was observed on quality parameters of extruded snack product during storage period. The extruded snack packed in low density polythene showed greater changes to moisture content and hardness in comparison to aluminium laminated pouches during storage in ambient and accelerated storage conditions. But the higher variation in quality parameters was observed at accelerated storage condition in comparison to the ambient storage condition. It may be concluded that extruded product packed in aluminium laminated pouches can be stored for a longer time period than low density polythene in both storage conditions. Hence, it is recommended to produce extruded snacks by the efficient utilization of the by-products from food industry as these are good source of proteins, minerals, fiber, bioactive compounds and can serve as an important raw material for the development of functional foods.

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