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Storage Stability Assessment of Extruded Rice and Maize Based Snacks Enriched with Fish

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Abstract This study aimed at the assessment of the storage stability of extruded snacks prepared by incorporating fish mince in rice and maize. The fish-rice and fish-corn extruded snacks were prepared at optimized processing conditions, packed in high density polyethylene and were stored at ambient storage condition for 120 days. The extruded snacks were regularly evaluated at a 15 days' interval for moisture content, water activity, free fatty acid content, hardness and overall acceptability during storage period. The results of this study revealed that moisture content, water activity and free fatty acid content increased during storage. Marginal decrease in the hardness and overall acceptability of stored extruded snacks was noticed. No detrimental changes have been noticed during the entire storage period and the products were found in acceptable quality limit after 120 days of storage at ambient conditions.

Keywords: *fish, extruded snacks, storage, free fatty acids, water activity*

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1. Introduction

Traditional snack items, such as roasted peanut plantains and potato crisps (Chips), are being replaced by fabricated alternatives, usually produced using an extruder. Some benefits of the fabricated alternatives over the traditional processes include less expensive raw materials, less wastage and greater control [1]. Another added commercial advantage of the convenience food (snack) is that people are willing to pay disproportionately large sums for snack items. For its high versatility and its peculiar ability to modify the physico-structural properties of products, extrusion-cooking technology has been used for a large number of applications. Extruded snacks are among the most well-known products obtained from such technology. Actually, the high content in starch and the poor presence of lipids make cereals an optimal raw matter for this application [2]. In this perspective, wheat, rice and maize, being common cereals consumed worldwide become obvious choice for the manufacture of such extruded products. However, wheat being high in protein and fiber impede the expansion during extrusion.

Rice (Oryza sativaL.) is a staple food for more than 60% of the world's population, especially in Asia [3]. As a primary dietary source of carbohydrates, rice plays an important role in meeting energy requirements and nutrient intakes [4]. Maize (Zea Mays L.), also known as corn, is one of the major cereal grains, maize is a staple food for large groups of people in Latin America, Asia, and Africa. The annual global production of Maize is about 780 million metric tons, of which the United States and China produce more than 40 and 20%, respectively. Maize is proverbially utilized directly for human food all over the world. In the United States, Maize is widely processed into various types of products, such as cornmeal, grits, starch, flour, snacks, tortillas, and breakfast cereals [5].

The cereals are supplemented with various functional ingredients in order to improve the nutritional value of resultant extruded products. Fish, owing to its high nutritional value, particularly, polyunsaturated fatty acids and other micronutrients, presents ideal ingredient to be incorporated in extruded foods with cereals.

Many cereal and snack products are dry foods containing lipids. Having a water activity below 0.6 they are stable against microbial growth, but chemical and enzymatic reactions can occur, which results in deterioration [6]. Products like peanut pork scratching and muesli have a high content of unsaturated fatty acids and are therefore very susceptible to lipid oxidation, resulting in formation of off-flavors during storage. From a food packaging perspective the effect of oxygen pressure and humidity on the oxidative stability of snack and cereal products is of major concern and may be decisive of the choice of initial headspace gas composition, initial product water activity and gas and water vapor permeability of the packaging material [7].

Although a few studies on the shelf-life of indigenous snack foods [8] and the improvement in food quality of extruded corn meal snack through protein fibre supplementation [9] have been reported, the storage stabilities of extruded indigenous maize-based snack foods have not been investigated. Hence the present investigation was undertaken with the objective of evaluating the storage stability of fish supplemented rice and corn based extruded snacks.

2. Materials and Methods

2.1. Sample Preparation

Freshly harvested Indian major carp (Cirrhinus mrigala) was obtained from College of Fisheries, Guru Angad Dev Veterinary and Animal Sciences University (GADVASU), Ludhiana, Punjab, India. The fish were de-scaled, beheaded, eviscerated and washed with potable water. The dressed fish was cooked by boiling in water for 10-12 min under normal atmospheric pressure. The cooked fish was cooled, de-skinned and deboned manually. The separated cooked meat was dried in an electrically heated cabinet drier at 50°C. The dried fish muscle was powdered in a laboratory mill. The prepared fish flour was packed in high density polyethylene (HDPE) zipped pouches and stored in a refrigerator maintained at 7±1°C. Broken rice (var. PR-106) was procured from local rice mill and ground to pass through 200 μ sieve using lab mill (Perten Intruments, Hagersten, Sweden). The proximate compositions of fish-rice and fish-maize flours were determined using the standard procedures of [10]. Several preliminary trials were made to select the proportion of fish flour incorporation in rice flour. The broken-rice flour was mixed with the fish flour in the proportion of 85:15 in the ribbon blender (G L Extrusion systems, New Delhi, India) for 10 minutes to ensure uniform mixing. Salt was added at 2 % into the mix and again blended for 5 m.

Table 1. Proximate composition of the raw materials

Ingredients	Parameters					
	Moisture content (%)	Crude protein (%)	Crude fat (%)	Crude fibre (%)	Ash	Carbohydrate (%)
Rice flour	8.23	6.59	0.33	0.85	0.71	83.29
Maize flour	8.68	6.82	0.56	1.35	0.54	82.05
Fish flour	7.09	82.61	3.09	-	5.72	1.49
Fish-maize	8.24	81.3	3.4	1.2	5.7	78.41
Fish-rice	8.01	78.2	4.03	0.9	6.5	79.24

2.2. Extrusion

The fish-rice and fish-maize blends were subjected to extrusion cooking using twin screw co-rotating intermeshing extruder (BC 21, Clextral, Firminy, France). The extrusion of fish-rice blend was carried out at 14-18% moisture content 125-175°C barrel temperature and rpm screw speed while for extrusion of fish-corn blend the extrusion processing conditions, 14.27-15.12% feed moisture, 173.61°C barrel temperature and 400-463rpm screw speed, were used. These extrusion processing conditions were optimized in the previous experiment by response surface methodology. The extrudates were cut in about 4-5 cm length cylindrical snacks by adjusting the speed of cutter. The snacks were cooled, packed in high density polyethylene packs until further analysis

2.3. Storage

The extruded snacks were stored in high density polyethylene packs and stored at ambient storage conditions (temperature, 25-350C; relative humidity, 50-75%) and evaluated for various quality parameters such as moisture content, water activity, free fatty acid content, hardness and overall acceptability over 120 days of storage at a 15 days' interval.

2.4. Quality Evaluation

2.4.1. Moisture Content

Weighed sample (2 g) were dried in a hot air oven at 130±1°C for 1 hr., and moisture content in percent was calculated from loss in weight of sample [10].

2.4.2. Water Activity

Water activity of extruded snacks during storage period was estimated by using water activity meter hygrolab (Retrogenic Company) having 3 bench-top indicators. Sample cup was filled up to half of its volume with sample and placed into water activity meter after well setting and calibration. Readings were displayed automatically after 5 minutes on the screen, and expressed as aw.

2.4.3. Free Fatty Acids

Standard [10] procedure was followed for free fatty acid estimation with slight modification. Weighed (5 g) sample was taken in flask. Fifty ml benzene was added in the sample and it was kept for 30 min and extract was filtered. For extraction of free fatty acids, 5 ml extract was taken in flask, added 5 ml benzene, 10 ml alcohol and two drops of phenolphthalein indicator and was titrated against 0.02N KOH till light pink colour disappeared. Free fatty acid (FFA) content of the sample was expressed as per cent oleic acid and calculated by using following formula.

$$FF(\%\,Ol) = \frac{282 \times 0.02N\ KOH \times ml\ of\ Al \times Df}{100 \times W} \times 100 \quad (1)$$

Where Df, Ol, Al and W are dilution factor, oleic acid, alkali used, and weight of sample taken, respectively

2.4.4. Hardness

Textural quality of the extruded snacks was examined by using a TA-XT2i Texture Analyzer (Stable Microsystems, Surrey, UK). The compression probe (50 mm dia, aluminium cylinder) was applied to measure the compression force required for samples breakage which indicates hardness. Hardness of extruded snacks was expressed in Newton (1N = 101.97 g force). Testing conditions were 1.0 mm/s pre-test speed, 2.0 mm/s test speed, 10.0 mm/s post-test speed and 5 mm distance [11].

2.4.5. Overall Acceptability

Products were evaluated for sensory attributes (appearance, texture, flavor and over all acceptability) through a panel of ten semi-trained judges using 9- point hedonic scale [12].

2.5. Statistical Analysis

Proximate composition was expressed at 14 per cent moisture. Values were mean of three replications. The data collected from aforesaid experiments were subjected to statistical analysis with the help of factorial completely randomized design. The least significant difference (LSD) was used as the test for significance [13].

3. Results and Discussion

3.1. Moisture Content

The moisture content of both, fish-rice and fish-maize, extruded products varied very narrowly Figure 1. The moisture content of fish-rice and fish-maize extruded products at 0 days were 5.58 and 5.71 per cent respectively, which increased to 7.18 and 7.26 per cent at the end of 120 days of storage. This slight increase in moisture content might be attributed to the hygroscopic nature of extrudates, as has been observed by [14]. Similar increase in moisture content of mulberry supplemented Thai rice extruded snacks was reported by [15] during storage of 4 months. Ref. [14] observed an increase in moisture content in breakfast cereals during a storage period of six months. They also concluded that there was intermediate gain in moisture through HDPE as compared to aluminum foil which has high moisture barrier properties. However, [16] did not observe significant increase in mung bean snacks during storage.

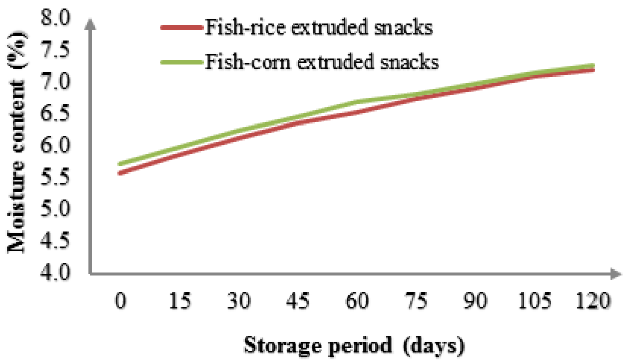

Figure 1. Effect of storage period on the moisture content of extruded snacks

The increase in moisture content of extruded products during storage period observed in this study was under safe limit, as [17] mentioned that the water content should be below 14 % to prevent the microbial growth and chemical changes during storage.

3.2. Water Activity

The changes in water activity of extruded snacks prepared from fish-rice and fish-maize during storage are illustrated in Figure 2. The water activity of extruded snacks increased marginally over entire storage period. However, it could be seen from Figure 2 that the trend of increasing water activity ceased as the end of storage period approached. Moreover, it could also be observed from Figure 1 and Figure 2 that the changes in water activity of extruded snacks were similar the changes in moisture content. Ref. [15], studied storage of iron fortified Thai rice snacks for 4 months and found that there was increase in water activity from 0.24 to 0.30 aw. Shelf life analysis of high iron precooked rice porridges charted a water activity of less than 0.51, although the value increased with storage time of 3 months [18]. The water activity is often used as an indicator of free water present in the sample over the bound water. This water participates in chemical reactions, if any, and is available for the microbial growth. However, micro-organisms are unable to grow below 0.5 aw and hence the extruded snacks evaluated for storage stability in this study would not pose a microbial risk.

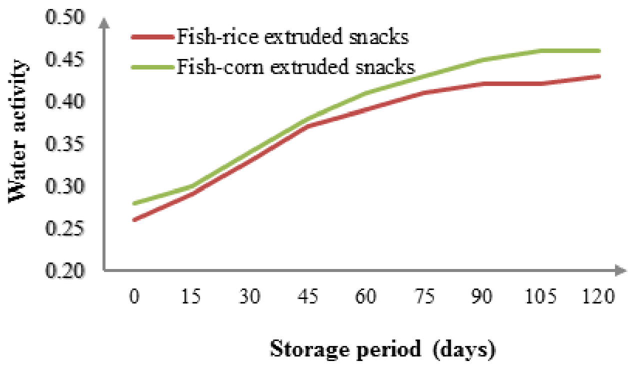

Figure 2. Effect of storage period on water activity of extruded snacks

3.3. Free fatty acids

Free fatty acid content expressed as per cent oleic acid increased during storage period Figure **3**. Initial value of free fatty acid in fish-rice and fish-maize extruded snacks was 0.38 and 0.42 per cent, respectively, which rose to 0.75 and 0.87 per cent at the end of storage period. Free fatty acids are developed by hydrolysis of fat present in the sample. This hydrolysis may be hydrolytic, induced by moisture, or oxidative, catalyzed by presence of oxygen at high temperature.

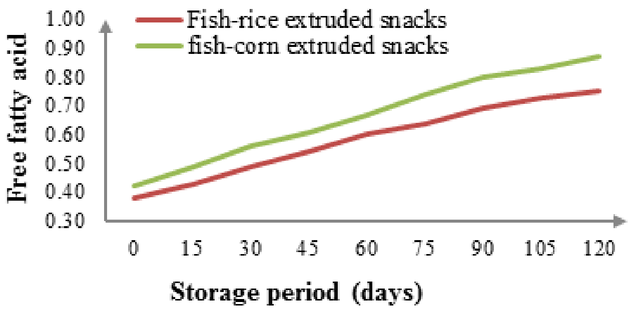

Figure 3. Effect of storage period on free fatty acid content of extruded snacks

The incorporation of fish, which is considered as good source of fats, particularly, polyunsaturated fats, might have hastened the onset of such hydrolysis and thus production of free fatty acids. Figure 3 also illustrated that the production of free fatty acids in corn based extruded snacks was more as compared to rice based extruded snacks. This could be due to higher amount of fat present in the corn than rice. The higher free fatty acid content of the food sample is detrimental to the quality and storage stability because it may result in rancidity, the production of off flavor through generation of free radicals, peroxides and hydro-peroxides. Ref. [19] reported that the breakage of long chain fatty acid chain into individual fatty acid moieties results in lipid hydrolysis at elevated temperature. Ref. [20] also observed that free fatty acid content of all the edible oil blends increased steadily from 0-60 days of storage of the fish-rice extruded snack. It was also reported that fat acidity correlates with the period of storage during initial stages [21], which seems consistent result with respect to this study. This study outlined that the free fatty acid content of stored extruded snacks was under control and no strong indication of rancidity was found.

3.4. Hardness

The alterations in textural quality with respect to hardness of stored extruded snacks are presented in Figure 4. Hardness of the fish incorporated rice and corn based extruded snacks stored for 120 days decreased slightly. This decrease may, probably, have been attributed to the increased moisture content of extruded snacks during storage.

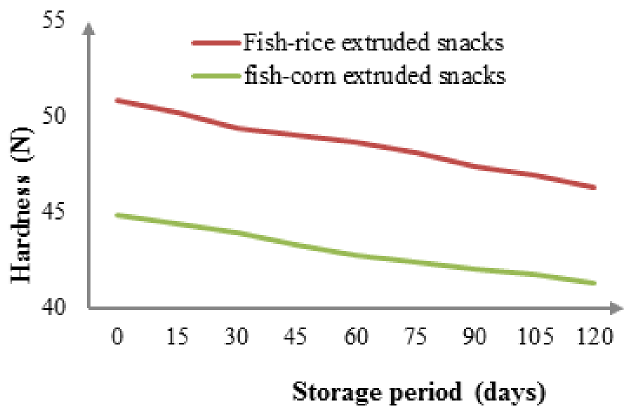

Figure 4. Effect of storage period on hardness of extruded snacks

The hardness of food sample such as snacks is the measurement of minimum force required for a probe to penetrate in the sample. Absorption of moisture would result in decreased strength of matrix holding the air bubbles which are responsible for voids and crispiness of the products. As a consequence of which product becomes more soggy and less crispy and hence would require less force for the probe to penetrate inside the product. This could be evidenced from the negative correlation between moisture content and hardness of the extruded snacks.

3.5. Overall Acceptability

The trends observed in overall acceptability of extruded snacks during storage are reflected in Figure 5. It could be seen from the Figure 5 that the overall acceptability of, fish-rice and fish-maize, extruded products decreased during storage period. However, the degree of decrease is less and the products remained acceptable at the end of storage period.

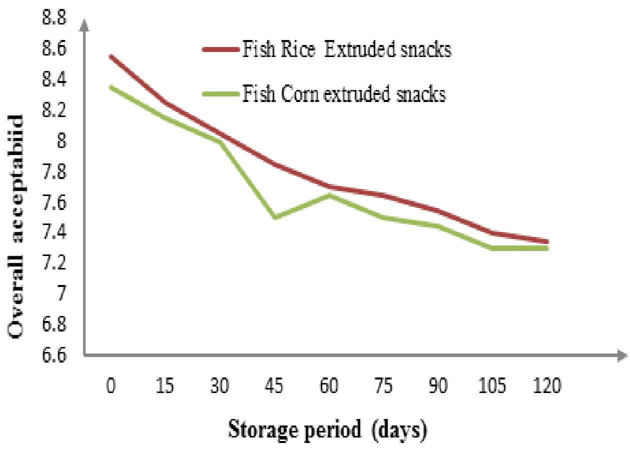

Figure 5. Effect of storage period on overall acceptability of extruded snacks

The freshly prepared extruded products were found in the range of “liked very much to liked extremely” when presented to semi-trained panel members for the sensory evaluation. This scale of likeness, though, decreased constantly during the storage period. The overall acceptability score of rice-fish and fish-maize extruded snacks at the end of storage period was 7.35 and 7.30, respectively, suggesting that these products were still highly acceptable to the panel members. The increase in moisture content, water activity, free fatty acid content and decrease in hardness might be responsible for the decreased overall acceptability of the stored extruded snacks.

4. Conclusion

The high amount of protein and fat content in fish and less in rice and maize but high carbohydrate content in rice and maize was main objective of incorporation to improve their nutritional value

Fish incorporated rice and maize based extruded snacks displayed small variations in the quality characteristics stored for 120 days at ambient storage conditions. The increase in moisture content, water activity, and free fatty acid content was evident. The hardness and overall acceptability of these products decreased trivially during storage. The products, however, were found shelf stable as they did not undergo drastic quality changes. The extruded snacks after 120 days of storage were found in acceptable range in spite of small changes in the quality characteristics.

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