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Effect of storage on quality of amaranth based farali (Suitable for fasting) extruded snack

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Abstract
This study was conducted to investigate effect of storage period on the selected quality parameters of extruded snack developed using amaranth grain, potato and whey protein. The extruded snack was packed in metallized laminate pouches (85±1.0 µm) and stored at ambient temperature. The changes in the moisture content, free fatty acids, sensory attributes, textural properties, and microbial counts were observed at every 15 days intervals for 90 days. There was a minor increase in moisture content of the extruded snack. The free fatty acid content significantly increased ($p<0.05$) on 45th day of storage. On 15th day of storage, hardness increased significantly, while fracturability decreased significantly. The changes in the scores of colour and appearances were non-significant ($p>0.05$). The significant reduction ($p<0.05$) in flavour and aftertaste score was observed on 75th day of storage, in body and texture and overall acceptability score was observed on 60th day of storage. The standard plate count increased, while coliform count and yeast and mold counts were absent during the whole storage period. The results of the ambient storage study carried out for 90 days revealed that the extruded snack was stable and acceptable throughout the storage period.

Keywords: Extruded, amaranth, snack, storage study, whey

1. Introduction

Amaranth is a promising and nutritive pseudocereal, yet underutilized food crop. It belongs to the family *Amaranthaceae*, comprising of approximately 70 species and 400 varieties, among them *A. hypochondriacus*, *A. cruentus* and *A. caudatus* are common for grain production [1]. It is an excellent source of high-quality protein (14.5 to 15.1 percent), having ample amount of lysine and other essential amino acids generally lacking in cereals and legumes [2].

Grain amaranth also contains higher amounts of minerals like Zn, Ca, Fe, and vitamins like A, E, and folic acid than many other cereal grains [3]. The amaranth grain also possesses flavonoids, phenolic acids, anthocyanins, tannins, and phytosterols, which have been linked with the prevention and treatment of many chronic diseases. This speciality traits paves the ways to develop the nutritious snack products with amaranth.

Extrusion is a technology for preparing a wide range of food products which is an operation where, the transformation of food biopolymers takes place through thermo-mechanical means of mixing, kneading, shearing, heating, gelatinizing, plasticizing, compressing and texturizing through moulding from a die in a single unit operation [4]. These days, extruded snacks are gaining popularity among all age group people, owing to their ready-to-eat nature, appealing look, delicious taste and less fat composition.

Fasting is an integral part of Indian culture and tradition which has been scientifically proven for the mental and health benefits associated with it. Usually, during fasting the farali foods made from amaranth, sago, tubers, and fruits are consumed. However, only few farali products are commercially available such as potato chips, banana chips, and farali chivda which are high in fat [5]. So a healthy farali snack was manufactured from amaranth, potato flour and whey protein. The nutritional value of whey protein is also well-known, while the potato (*Solanum tuberosum* L.) provides 'patatin' protein and key functionalities for extrusion, so they can become the choicest ingredient for extruded snacks. The present investigation was intended for studying the storage related changes in the packaged amaranth based extruded snack.

2. Material and Methods

2.1 Raw materials preparation

Amaranth grains (*Amaranthus hypochondriacus* var. GA-3) were procured from the local farmers of Anand district. Potato flour was procured from Iscon Balaji Foods Pvt. Ltd., Gujarat. WPC-70 was purchased from Indipro Pvt. Ltd., Ahmedabad. Good quality rock salt was procured from the local market. The amaranth grains were cleaned and milled in lab scale hammer mill. The flour was then packed into an airtight container. WPC and potato flour were also sieved and packed into an airtight container till further use.

2.2 Extruded snack preparation

The above raw ingredients, *viz.* amaranth flour, potato flour and WPC (11.3:9.3:1) were weighed and added with pulverized rock salt at 1.5 g/100 g flour mix. The moisture content of the flour mix was adjusted to 14% by adding calculated quantity of water, mixing and preconditioning overnight at refrigerated temperature.

Extrusion processing was carried out in a laboratory scale co-rotating twin-screw extruder (Basic Technology Pvt. Ltd., Kolkata, India). The extruder had two-barrel zones and length to diameter ratio (L/D) was 11.66:1. Temperatures of first zone and second zone (die section) were maintained at 60 °C and 129 °C (optimized) respectively, the feed rate was 86.2 g/min at 17 rpm of feed augers. The screw speed was kept constant at 287.5 rpm. The product was extruded out through a cylindrical die having a 4.0 mm orifice and dried at 60 °C for 90 min in a tray drier and then cooled to room temperature, followed by packaging into metallized laminate pouches (85±1.0 µm) and stored for three months under ambient conditions (32±2 °C). The moisture content, free fatty acids, sensory attributes, textural properties, and microbial counts were observed at every 15 days intervals up to 90 days.

2.3 Analysis of extruded snack

Moisture content was analyzed using standard procedure of FSSAI (2016) [6]. Standard AOAC procedures [7] were followed for analysis of free fatty acids determination, the standard plate count, yeast and mold count, and coliform count were determined according to procedure described by Ranganna (2004) [8]. Hardness and fracturability of the extrudates were measured with the help of a 3-Point Bending Rig probe (HDP/3PB) using a 5.0 kg load cell on texture analyzer (TA-HD plus, Make: Stable Micro Systems, Surrey, UK). The test was run by using Exponent connect software after setting Pre-Test Speed 1.0 mm/s, Test Speed 1.0 mm/s and Post-Test Speed 10.0 mm/s. The sensory scores for color and appearance; flavor and aftertaste; body and texture; and overall acceptability were obtained on a 9-point hedonic scale.

2.4 Statistical analysis

All the experiments were carried out in triplicate. Experimental data were analyzed by one way ANOVA using Completely Randomized Design with 5% level of significance.

3. Results and Discussion

3.1 Effect of storage on moisture content of extruded snack

The moisture content of optimized extruded snack packed in metallized laminates showed no significant change (p>0.05) at the end of 90 days of storage at room temperature as shown in Table 1. The insignificant rise may be attributed to the structural changes like retrogradation of starch or change in equilibrium moisture content inside the package or mild moisture ingress from the packaging material.

Chaudhari *et al*. (2020) [9] observed the increase in moisture content of whey protein concentrate-based extruded snack food from 3.50 to 5.30 percent after 180 days of ambient storage. The moisture content of extruded products, packed in MET-PET and stored at room temperature for 120 days, increased from 3.41 to 5.15 percent for ragi and milk solid based snack (Kumar, 2020) [10], while 3.65 to 4.88 percent for ragi and milk solid based snack (Panchal, 2020) [11].

3.2 Effect of storage on free fatty acid (FFA) content of extruded snack

The FFA content of the extruded snack increased from 0.029 to 0.050 percent as oleic acid after 90 days of ambient storage (Table 1). This increase is due to oxidation of high amount of unsaturated fatty acids available in amaranth flour [2]. The first significant change (p<0.05) in FFA content was observed on 45th day of storage. The observed delay in oxidation is due to use of metallized laminates with high barrier properties which limits the transmission of light and oxygen. The increase in FFA content after 90 days of storage was within the permissible limit of 0.25 percent by weight as specified by FSSAI (2011) [12]. Pawar *et al*. (2012) [13] reported an increase in FFA content from 3.25 to 3.66 percent as oleic acid in egg-based snack food packed in MET-PET and stored for 6 months.

Table 1: Effect of storage period on moisture and free fatty acid content of extruded snack

Storage (days)	Moisture (%)	Free fatty acids (% oleic acid)
0	6.34±0.13	0.029^a±0.000
15	6.37±0.12	0.029^a±0.000
30	6.44±0.14	0.030^a±0.001
45	6.52±0.05	0.033^b±0.001
60	6.56±0.06	0.036^c±0.001
75	6.62±0.35	0.044^d±0.001
90	6.70±0.12	0.050^e±0.001
S.Em.	0.19	0.001
C.D.	NS	0.002
C.V. (%)	3.15	3.00

All the values are mean ± SD, (n=3); NS= non-significant (p>0.05); superscript a, b, c, d, e and f indicates critical difference between the means (p<0.05)

3.3 Effect of storage on the textural characteristics of extruded snack

The hardness of extruded snack during storage increased from 1127g to 1322g and fracturability decreased from 1.93 mm to 1.43 mm during 90 days of storage. The first significant changes (p<0.05) in hardness and fracturability were observed on 15th day of storage. The similar trend in hardness and fracturability was also observed in the different extruded snacks prepared using corn, soy, ragi, milk solids and moringa [9, 10, 11, 14]. This observed increase in hardness and decrease in fracturability can be attributed to the increase in the moisture content of the product leading to reordering and compaction of the expanded structure [15].

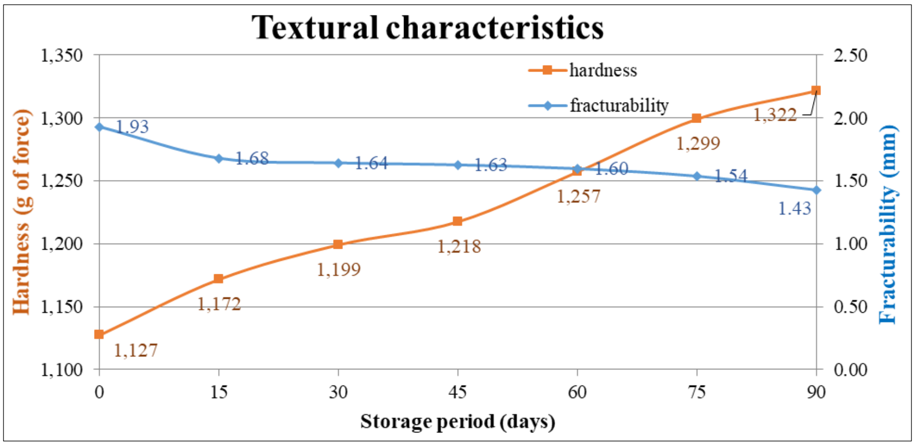

Fig 1: Changes in textural characteristics of extruded snack during the storage study

3.4 Effect of storage on the sensory characteristics of extruded snack

The results of the periodic sensory evaluations of the samples (Table 2) stored for 90 days revealed that the change in the colour and appearances was non-significant (P>0.05). The flavour and aftertaste score decreased from 8.07 to 7.44, where the first significant reduction was noticed on 75th day of storage. The body and texture and overall acceptability scores also decreased from 8.10 to 7.46 and 8.12 to 7.53 respectively, showing the first significant reduction on 60th day of storage. At the end of 90 days the sensory scores were above '7.0' indicating that the product was acceptable.

Storage changes of the extruded products prepared from corn [16, 17] and defatted watermelon seed cake flour [18] and stored at room temperature for 90 days, were coinciding with the findings in the present study.

Table 2: Effect of storage period on sensory attributes of extruded snack

Storage period (days)	Sensory scores (out of 9)			
	Colour & Appearance	Body & Texture	Flavour & After taste	Overall Acceptability
0	8.24±0.24	8.10^{d}±0.23	8.07^{c}±0.24	8.12^{d}±0.25
15	8.11±0.16	8.05^{d}±0.24	8.04^{c}±0.24	7.98^{bcd}±0.15
30	8.07±0.22	7.98^{cd}±0.23	7.98^{c}±0.23	7.97^{bcd}±0.23
45	8.03±0.22	7.89^{bcd}±0.23	7.87^{bc}±0.23	7.87^{abcd}±0.23
60	8.00±0.22	7.65^{abc}±0.22	7.73^{abc}±0.23	7.74^{abc}±0.23
75	7.93±0.15	7.53^{ab}±0.19	7.59^{ab}±0.22	7.69^{ab}±0.20
90	7.88±0.20	7.46^{a}±0.22	7.44^{a}±0.22	7.53^{a}±0.11
S.Em.	0.12	0.13	0.11	0.12
C.D.	NS	0.39	0.40	0.36
C.V. (%)	2.91	2.61	2.16	2.46

All the values are mean ± SD, (n=3); NS= non-significant (*p*>0.05); superscript a, b, c, d, e and f indicates critical difference between the means (*p*<0.05)

3.5 Effect of storage on the microbial quality of the extruded snack

The yeast and mould and coliform counts were found to be absent in all the stored samples of the extruded snack analysed during the storage study. The significant (P<0.05) increase in the standard plate counts from 2.32 to 2.65 log cfu/g (Fig. 2) was observed during the 90 days of storage, yet meeting to the limit for total bacterial count (4.70 log cfu/g) of ready to eat extruded food as prescribed in BIS standards (1989) [19].

The similar increasing trend in SPC, while absence of yeast and moulds as well as coliforms was also reported in similar extruded snack products [9, 10, 11, 13, 14, 20]. The above microbial quality indices suggest better hygienic operations during food processing through extrusion.

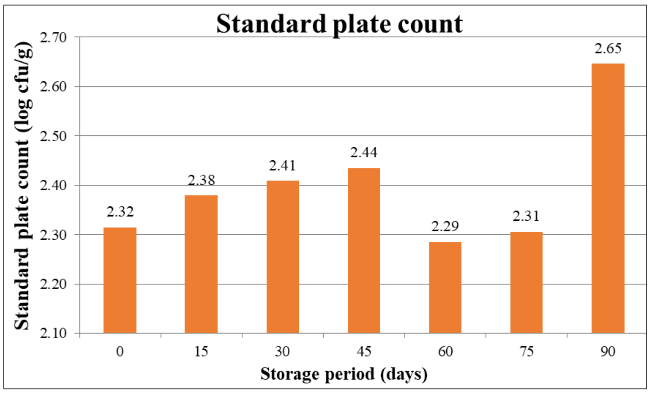

Fig 2: Standard plate counts (log cfu/g) of the stored extruded snack

4. Conclusion

The storage study is a very important measure before commercializing any food product. The results of the storage study of amaranth based farali (suitable for fasting) extruded snack showed that the free fatty acid content, hardness and fracturability, flavour and aftertaste score, body and texture score, overall acceptability scores, and standard plate count were significantly affected during storage while the moisture content and colour and appearance remained least affected. The packaging material played a role in limiting the above changes, keeping the product acceptable after 90 days of storage. The changes observed in each of the selected parameters can be useful in formulating research on products and packaging in future.

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