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Storage Stability of Extruded Normal Maize and Quality Protein Maize Based Extruded Products

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ABSTRACT

This study aimed at assessment of the storage stability of extruded products such as porridge and snacks prepared from normal maize and quality protein maize. The extruded products were prepared at optimized processing conditions and storage was done under ambient temperature after packaging in polyethylene (LDPE) and laminate pouches for 6 months. The extruded snacks were regularly evaluated at 1 month interval for moisture content, free fatty acid, water activity and overall acceptability during storage period. The results of this study revealed that moisture content, free fatty acid and water activity content increased during storage. Marginal decrease in the 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 at ambient conditions.

Key words: *Extruded snacks, storage, free fatty acids, water activity, Porridge*

INTRODUCTION

Snack foods become an important approach to deliver essential nutrients to the population because of change in life style and eating habits[14].Traditional cereal snack items such as roasted peanuts, potato crisps (chips) were supposed to be unhealthy because of high fat and sugar content while these snacks contain low level of essential nutrients. To overcome this problem, food industry induces extruded fortified snack foods by incorporating functional ingredients. The benefits to produce extruded products include acceptability and feasibility such as greater control, less wastage and less expensive raw material[15, 18]. People become adaptable to extruded snack food because of their flexible food uses and their ability to modify the physico-structural properties of products. Extrusion processing generally requires starch based raw material basically cereals[4]. In this perspective, wheat, rice and maize, being common cereals consumed worldwide become choice for the manufacture of such extruded products. However, wheat being high in protein and fiber impede the expansion during extrusion.

Maize (*Zea mays* L.) also known as corn, is the member of Ponicoidae subfamily. It is major cereal grains and staple food for large groups of people in developing countries.

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Maize is utilized in various forms ranging from immature grains to maize products directly for human food all over the world. It is widely processed and used into considerable range of products, such as snacks, tortillas, chips, cornmeal, starch, grits, flour and breakfast cereals[13].The cereals are supplemented with various functional ingredients in order to improve the nutritional value of resultant extruded products. Quality protein maize owing to its high nutritional value, particularly, presence of essential amino acids such as lysine and tryptophan provide wide opportunities to prepare nutritionally enriched extruded foods from cereals.

The storage quality of extruded products is mainly depends upon their fat content, moisture content and water activity. Water activity influences the stability of products as under low water activity microbial growth stops but chemical and enzymatic reactions can occur and results in food product deterioration[11]. Moisture content of any product is the predominant parameter defining the stability and thus shelf life. Packaging of food is also a major concern to determine the oxidative stability of cereal snack products with respect to the effect of oxygen pressure, humidity and water vapor permeability of the packaging material[17].

Few studies have been conducted to determine the shelf-stability of extruded products during storage[9]. Hence, the present investigation was undertaken with the objective of evaluating the storage stability of normal and quality protein maize based extruded snacks and porridge.

MATERIAL AND METHODS

Raw material:

Normal maize (var. PMH-1) and Quality protein maize (var. HQPM-1) was procured from Directorate of seed and Indian institute of Maize research, Punjab Agricultural University, Ludhiana, Punjab, India.

Extrusion

A twin screw co-rotating intermeshing extruder (BC 21, Clextral, Firminy, France) was used for extrusion cooking of normal and quality protein maize flour. The configuration of screw is presented in fig. 2. The extrusion was carried out at 14-18% feed moisture, 125-175ºC barrel temperature and 450-550 rpm screw speed. These extrusion processing conditions were optimized in the previous experiment trials by response surface methodology. The extrudates were cut by adjusting the speed of cutter. The snacks and porridge prepared from both varieties were packed (polythene and laminates) and stored for further analysis.

Storage

The extruded products were stored at ambient temperature after packaging in polyethylene packs and laminate pouches (temperature, 25-35^{0}C) and evaluation was done for various quality parameters such as moisture content, free fatty acid and overall acceptability over 6 months of storage at 1 month interval.

Product Analysis

Moisture content

Moisture content of the extruded snacks was determined by drying of pre-weighed sample (2 g) for 1 hr in a hot air oven at 130±1^{o}C. Moisture content was calculated in percent[1].

Free Fatty Acids

Free fatty acid content was estimated by following standard procedure[2] with slight modification. 5 g of dried sample was mixed with 50 ml benzene in flask and placed for 30 min for extraction of free fatty acids. To 5 ml of extract obtained after filtration, 5 ml benzene, 10 ml alcohol was added. Titration was performed against 0.02N KOH after addition of two drops of phenolphthalein indicator 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.

$$\text{FFA (as \% oleic acid)} = \frac{282 \times 0.02\text{N KOH} \times \text{ml. of alkali used} \times \text{dilution factor}}{1000 \times \text{Weight of sample taken}} \times 100$$

Overall acceptability

Extruded products were evaluated by a panel of ten semi trained judges, on the basis of sensory attributes such as appearance, flavor and texture and over all acceptability. Sensory evaluation score was considered using 9- point hedonic scale[12].

Statistical Analysis

Statistical analysis of the collected data of experiments was carried out with the help of analysis of variance (ANOVA) using duncan's multiple range test. The experiments were performed in replicates.

RESULT AND DISCUSSION

The extruded products prepared from normal maize and quality protein maize at optimized processing conditions were evaluated for various quality characteristics, which are likely to influence the consumer acceptability such as moisture content, free fatty acid content and overall acceptability were assessed after every 30 days. The effect of storage conditions and duration on the quality of extruded products is described in the following sections.

Moisture content

The moisture content of both porridge and snacks samples packed in polyethylene and laminated pouches varied very narrowly (Table 1, 2). The moisture content of NM based extruded porridge and snacks in polythene and laminate pouches at 0 day was 3.71 and 5.27 per cent respectively, which increased to 5.81 and 6.99 per cent ; 5.69 and 6.87 at the end of 180 days of storage, respectively. The gain in moisture content of QPM based porridge and snacks packed in polyethylene and laminated pouches also showed an increase in moisture content. This slight increase in moisture content might be attributed to the hygroscopic nature of extrudates, as has been observed by Butt *et al*[5]. Similar results for moisture content of mulberry supplemented Thai rice extruded snacks were reported by Charunuch *et al.*[6] during storage period of 4 months. Butt *et al.*[5] noted a rise in moisture content of breakfast cereals during six month storage period. They also concluded that there was intermediate gain in moisture through HDPE as compared to aluminium foil which has high moisture barrier properties. However, Cheng *et al.*[7] did not observe significant increase in moisture content of mung bean snacks during storage. Pyler[16] stated that under storage conditions water content below 14 percent helps to prevent the microbial and chemical changes.

Free fatty acids

Free fatty acid content expressed as per cent oleic acid increased during storage period (Table 3, 4). Initial value of free fatty acid in QPM extruded snacks and porridge was 0.14 and 0.18 per cent, respectively, which rose to 0.84 and 0.97 per cent at the end of storage period in polyethylene packs.

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. Table 3,4 also illustrate that the production of free fatty acids in QPM and NM corn based extruded products in laminates is less as compared to polyethylene packs..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. Khan *et al.*[10] reported that a elevated temperature the long chain fatty acid break downs to individual or small fatty acid moieties and leads to lipid hydrolysis. Gulla *et al.* [8] also observed that free fatty acid content of all the edible oil blends increased steadily from 0-60 days of storage of the RTE extruded snack. It was also reported that fat acidity correlates with the period of storage during initial stages[3], 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.

Overall acceptability

Fig. 1 (a, b) showed that the overall acceptability of extruded products packed in laminates and polyethylene bags. The data showed that acceptability of products was decreased during storage period. However, the degree of decrease is less and the products remained acceptable at the end of storage period. The scale of likeness, though, decreased constantly during the storage period. The overall acceptability score of QPM based porridge and NM based extruded snacks at the end of storage period were 8.5 and 8.0, respectively, suggesting that these products were still highly acceptable to the panel members. The rise in moisture content and free fatty acid might be responsible for the decreased overall acceptability of the stored extruded snacks.

Table 1: Effect of storage period on moisture content (%) of the extrudates packed in polyethylene pouches

Storage period (Days)	Moisture content (%)			
	A	B	C	D
0	3.71± 0.09g	2.14± 0.04g	5.27± 0.07g	3.27± 0.06g
30	3.97± 0.12f	2.50± 0.07f	5.68± 0.05f	3.57± 0.11f
60	4.28± 0.07e	2.89± 0.13e	5.97± 0.09e	3.86± 0.14e
90	4.70± 0.65d	3.12± 0.21d	6.25± 0.06d	4.29± 0.08d
120	4.94± 0.33c	3.45± 0.08c	6.57± 0.12c	4.77± 0.05c
150	5.44± 0.12b	3.87± 0.06b	6.89± 0.09b	5.10± 0.02b
180	5.81± 0.22a	4.05± 0.13a	6.99± 0.03a	5.36± 0.01a

Values are written as Mean± Standard deviation,
Means with different superscript letters are significantly different according to the Duncans's multiple range test (p≤0.05)
A- Normal maize porridge; B- Quality protein maize porridge; C- Normal maize snacks; D- Quality protein maize snacks

Table 2: Effect of storage period on moisture content (%) of the extrudates packed in laminates

Storage period (Days)	Moisture content (%)			
	A	B	C	D
0	3.71± 0.12^{g}	2.14± 0.13^{g}	5.27± 0.22^{g}	3.27± 0.22^{g}
30	3.88± 0.09^{f}	2.46± 0.05^{f}	5.45± 0.22^{f}	3.40± 0.22^{f}
60	4.18± 0.05^{e}	2.77± 0.07^{e}	5.77± 0.22^{e}	3.71± 0.22^{e}
90	4.53± 0.11^{d}	2.97± 0.14^{d}	6.12± 0.22^{d}	4.02± 0.22^{d}
120	4.85± 0.06^{c}	3.27± 0.04^{c}	6.46± 0.22^{c}	4.45± 0.22^{c}
150	5.29± 0.09^{b}	3.67± 0.01^{b}	6.78± 0.22^{b}	4.77± 0.22^{b}
180	5.69± 0.12^{a}	3.89± 0.05^{a}	6.87± 0.22^{a}	5.20± 0.22^{a}

Values are written as Mean± Standard deviation
Means with different superscript letters are significantly different according to the Duncans's multiple range tests (p≤0.05).

Table 3: Effect of storage period on free fatty acid (%) of the extrudates packed in Polyethylene packs

Storage period (Days)	Free fatty acid content (%)			
	A	B	C	D
0	0.12± 0.02^{g}	0.14± 0.03^{g}	0.17± 0.01^{g}	0.18± 0.02^{g}
30	0.23± 0.01^{f}	0.25± 0.12^{f}	0.26± 0.04^{f}	0.28± 0.04^{f}
60	0.36± 0.06^{e}	0.37± 0.15^{e}	0.39± 0.12^{e}	0.42± 0.07^{e}
90	0.42± 0.11^{d}	0.47± 0.04^{d}	0.50± 0.08^{d}	0.51± 0.12^{d}
120	0.50± 0.07^{c}	0.55± 0.08^{c}	0.57± 0.18^{c}	0.59± 0.10^{c}
150	0.64± 0.03^{b}	0.72± 0.11^{b}	0.77± 0.15^{b}	0.80± 0.21^{b}
180	0.75± 0.02^{a}	0.84± 0.14^{a}	0.90± 0.19^{a}	0.97± 0.17^{a}

Values are written as Mean± Standard deviation,
Means with different superscript letters are significantly different according to the Duncans's multiple range test (p≤0.05)

Table 4: Effect of storage period on free fatty acid (%) of the extrudates packed in laminate packs

Storage period (Days)	Free fatty acid content (%)			
	A	B	C	D
0	0.12± 0.02[g]	0.14± 0.01[g]	0.17± 0.01[g]	0.18± 0.04[g]
30	0.20± 0.05 [f]	0.21± 0.06[f]	0.23± 0.07[f]	0.24± 0.09[f]
60	0.34± 0.03[e]	0.33± 0.13[e]	0.36± 0.05[e]	0.40± 0.11[e]
90	0.40± 0.09[d]	0.44± 0.24[d]	0.48± 0.11[d]	0.50± 0.17[d]
120	0.48± 0.14[c]	0.54± 0.12[c]	0.55± 0.17[c]	0.56± 0.21[c]
150	0.60± 0.11[b]	0.70± 0.05[b]	0.73± 0.21[b]	0.75± 0.18[b]
180	0.72± 0.09[a]	0.80± 0.12[a]	0.86± 0.25[a]	0.92± 0.21[a]

Values are written as Mean± Standard deviation,
Means with different superscript letters are significantly different according to the Duncans's multiple range test (p≤0.05)

Fig. 1a: Effect of storage period on overall acceptability of NM and QPM based extruded products (Laminate packs)

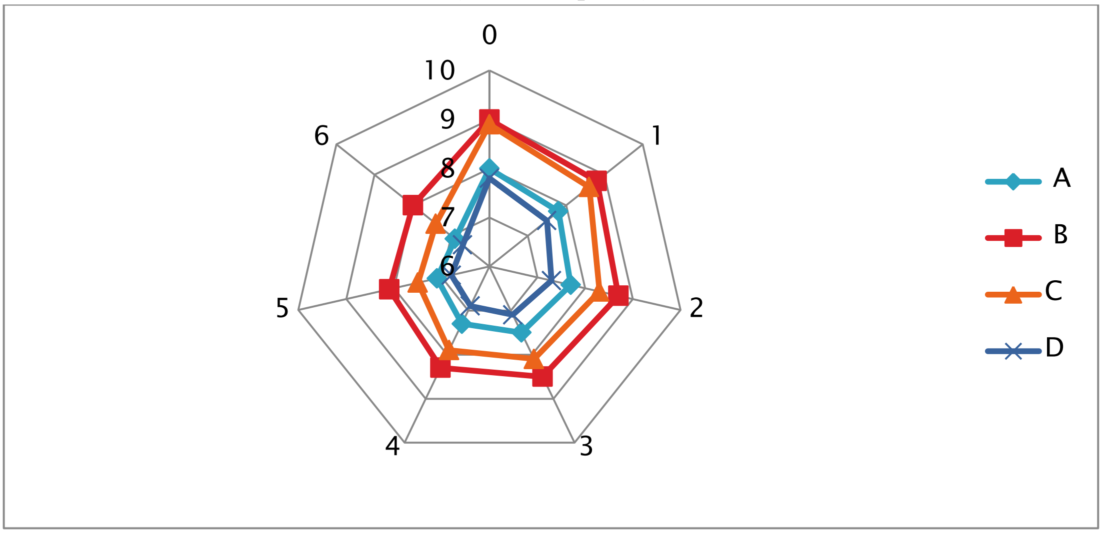
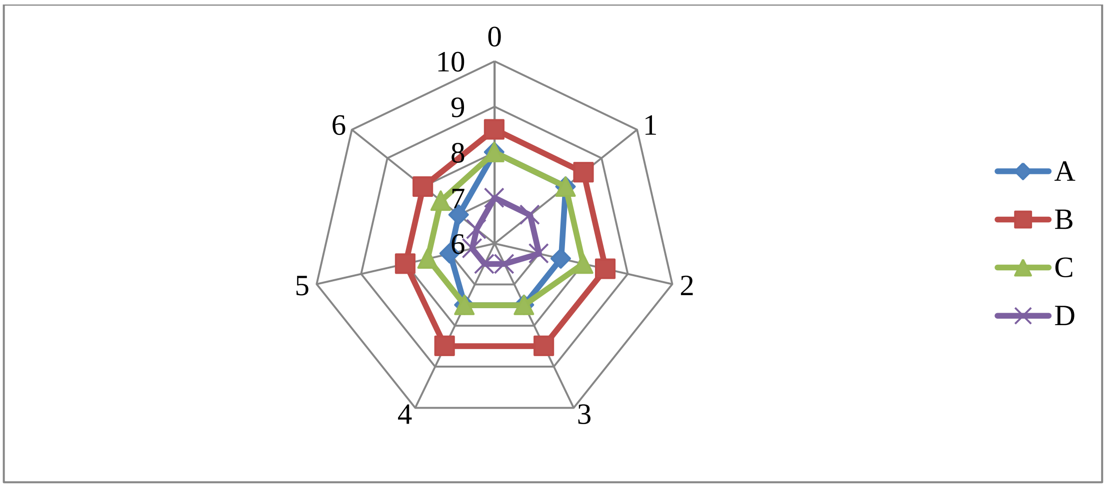


Fig 1b: Effect of storage period on overall acceptability of NM and QPM based extruded products (Polyethylene packs)



A- Normal maize porridge; B- Quality protein maize porridge; C- Normal maize snacks; D- Quality protein maize snacks

Fig. 2: Screw configuration for the extrusion trials

CONCLUSION

Normal and quality protein maize based extruded snacks and porridge showed small variations in the quality characteristics stored for 6 months at ambient storage conditions. Moisture content, free fatty acid changes were evident. The overall acceptability of these products decreased during storage. However, the products were found shelf stable as they did not undergo drastic quality changes.

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