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DEVELOPMENT AND QUALITY EVALUATION OF EXTRUDED FORTIFIED CORN SNACK

Deepika Balfour* Chitra Sonkar and Shakti Sharma
[1]Department of Food Process Engineering, Vaugh School of Agricultural Engineering and Technology SHIATS, Allahabad.
*Corresponding Author: reachdeepika87@gmail.com

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ABSTRACT

Extruded fortified corn snack was developed by single type screw extruder using Corn Meal, Oat Meal and Whey Protein Concentrate. The studies were conducted on incorporation of different ratios of CM, OM and WPC used and shelf life study was conducted for two months. Three different ratios of CM, OM and WPC were taken in the proportion of (90:7:3) for the first (80:16:4) second and (70:25:5) third treatment. Spinach and mint leaves were used for flavoring and seasoning. Physico-chemical and sensory analysis of the samples were evaluated. During storage it was observed that moisture content of the sample showed slight increase whereas there was a slight decrease in all the other proximate analysis. But it was observed that all the proximate parameters were increased from the control sample to the different treatments. Among the treatments the one with 80% and 70% CM were found nutritive. Depending upon the sensory attributes also the sample having 80% CM was found satisfactory for storage and is the most acceptable sample. Therefore the snack developed is a high fiber low calorie snack which can be recommended to the diabetic and obese people.

Keywords: Corn meal, Extrusion, Fortified snack, low calorie, Oat meal.

INTRODUCTION

A snack is a portion of food oftentimes smaller than that of a regular meal that is generally eaten between meals. Consumers these days demand for whole grain snacks that are low in fat, high in protein, high in dietary fiber and deliver balanced nutrition. Extrusion technology has taken the snack food category far from the domain of the potato chip and pretzel that dominated it for decades. Extrusion processing is popular in the food industry and can efficiently create novel products that might not be possible with other processing methods (Cisneros and Kokini 2002) such as snacks and ready to eat foods. Extrudates are microbiologically safe, can be stored for long periods because of low moisture without need for refrigeration and requires less labor for handling and less packaging materials and storage space (Filli and Nkama, 2007).

Extrusion cooking is a high-temperature; short-time (HTST) technology applied in many food production processes and considered as a continuous cooking, mixing, and forming process with low cost and high efficiency (Ryu et al., 1993; Abd El-Hady et al., 1998; Ding et al., 2005).) Extruder is a thermodynamic unit which involves the combination of heat, pressure and mechanical shear. The process is achieved by screw and barrel tube mechanism. Feed material in granular form are fed into the extruder barrel, then screw, then convey the material and compress and work in shear to transform the granular feed material into a semi solid plasticized mass the food is then extruded through an interchangeable die and cut at die either by rotating knives or subsequently by guillotine knives to form a variety of shapes. During extrusion, the cooking temperature could be as high as 180-190 °C; residence time is usually 20-40 seconds.

The results of cooking the food ingredients during extrusion are gelatinization of starch, denaturation of protein, inactivation of raw food enzymes, destruction of naturally occurring toxic substances, diminishing of microbial counts in the final product. Advantages of food extrusion are versatility, high productivity, low cost, product shapes, high product quality, and energy efficiency, production of new foods, and no effluents or waste.

Commeal is a meal (coarse flour) ground from dried maize. It is rich in phosphorus, magnesium, manganese, zinc, copper, iron and selenium. The fiber in commeal

helps to promote colon health and prevent constipation. The fiber in commeal lowers cholesterol levels. Commeal is gluten –free. It is beneficial for managing diabetes.

Oats (Avena sativa) provide one of the richest sources of the dietary soluble. It contains more lipids i.e. 5-9% (Peterson and Wood, 1997 ;) than any other cereal crops and is rich in unsaturated fats. The presence of total and free sugars in oats is very low in comparison to other cereal grains (Lambo, 2004). Oatmeal helps in fighting obesity as its soluble fiber slows down digestion. The important nutritional attributes of oats relate to the lowering of blood cholesterol and sugar (Webster, 1986).

Whey protein is a mixture of globular proteins isolated from whey, the liquid material created as a by-product of cheese production from milk.).Successful incorporation of whey into extruded products increases utilization of whey products and improve the nutrient density of snacks by increasing the protein content. Addition of whey protein can enhance their nutritional value because their incorporation in extruded products may provide a nutritionally sound and economical approach to fortification (Allen et al. 2007). Whey protein concentrate as a valuable source of proteins and minerals is one of the highest-quality components for possible extrudates enrichment.

Spinach has a high nutritional value and is extremely rich in antioxidants. It's low in calories yet very high in vitamins, minerals and other phytonutrients. Mints are aromatic herbs that have a distinct aroma and fragrance.

In this study extruded fortified corn snack was developed and the shelf life study of the snack was conducted for two months at an interval of 20 days on the basis of physico-chemical parameters and sensory attributes.

Extruded product developed will show good functional characteristics with improved health benefits (more fiber and protein content) due to whey protein and spinach addition to corn. The decision to adopt extrusion cooking was motivated by the need to improve nutritional status, physical state and the functionality of the end product.

MATERIALS AND METHODS

The materials such as corn meal, oat meal**,** whey protein concentrate, spinach powder, mint leaves powder, spices, oil, and salt were procured from the local market of Allahabad. The development of the extruded fortified corn snack was done at Cent Percent Food Products, Naini Industrial Area, Allahabad. The quality evaluation of the developed extruded fortified snack was done in the department of Food Process Engineering, SHIATS, Allahabad.

The experimental procedure of this study is shown as follow in table 1.

Corn meal was taken
↓
Addition of Oat Meal in different Proportions
↓
Addition of WPC
↓
Addition of Water
↓
Mixing of ingredients
↓
Extrusion of the mixture at 110-115°C
↓
Drying of the Extruded puffs
↓
Flavoring of the Extruded puffs with Mint Leaves Powder and Spinach Powder
↓
Packaging

Fig 1 Flowchart for the Development of Extruded Fortified Corn Snack for different treatments

Table 1 Formulation of Extruded Fortified Corn Snack

Ingredients	**Treatments**			
	T_0	**T_1**	**T_2**	**T_3**
Corn meal (%)	100	90	80	70
Oat meal (%)	_	7	16	25
Whey protein concentrate (%)	_	3	4	5
Spinach powder (%)	_	3	5	7
Mint leaves (%)	10	10	10	10

DEVELOPMENT OF EXTRUDED FORTIFIED CORN SNACK PHYSICO-CHEMICAL ANALYSIS

Crude Protein, Total Ash was determined by standard method given by (A.O.A.C., 1980).Crude fiber determined by the method of (A.O.A.C., 1984). Fat and Moisture content was determined by the method given according to (A.O.A.C., 1999). Iron content determined by the method of (A.A.C.C., 2000).Carbohydrate Content was determined by the Anthrone method. Ascorbic Acid Content was determined by titration method.

Sensory evaluation was conducted on 9-point Hedonic Scale. The samples were evaluated on the basis of 6 parameters; Color Taste, Flavor Appearance, Texture, Overall acceptability. The acceptance test was carried out using a structured hedonic scale, with extremes of 1 (disliked extremely) and 9 (liked extremely) to analyze the following attributes: appearance, color, texture, aroma and taste

The data recording during the course of investigation were subjected to statistical analysis by "Analysis of variance" technique (Fisher and Yates, 1968) for drawing conclusion. Two way ANOVA with replication was done. The significant and non-significant treatment affect was judge with the help of F (variance ratio) table. The significant different between the means was tested against the critical difference at 5% level.

RESULTS AND DISCUSSION

MOISTURE CONTENT

The effect of storage period on the moisture content of extruded fortified corn snack prepared with

different proportions of corn meal, oat meal, and whey protein concentrate is presented in Table 2.The moisture content was maximum in sample-T_0 (13.898%) followed by sample –T_1 (13.23%), and sample-T_2 (11.589%) and the least in sample T_3 (10.961) after 60 days of storage period. The lesser moisture content in the sample-T_3 may be attributed to the presence of more oat than other samples as oat contains maximum fiber so less was the amount of moisture content in the sample. Increase in moisture content has been associated with increase in fiber content (Akhtar et al., 2008; Elleuch et al., (2011).

The moisture content decreases considerably in different treatments from T_0 to T_3. A significant increase is observed in all the treatments from T_0 to T_3 with the increase in shelf life from 0 to 60 days. In treatment T_2 it was found that there was a slight increase in moisture content during its storage period which makes it more acceptable as compared to other treatments.

Table 2 Moisture Content

S.N0	0 Days	30 Days	60 Days
T_0 (%)	13.521	13.636	13.898
T_1 (%)	12.962	12.983	13.234
T_2 (%)	11.563	11.574	11.589
T_3 (%)	10.913	10.925	10.961
f- test	S	S	S
S.Ed. (±)	0.061251	0.135426	0.206324
C.D at (0.05)	0.136591	0.302001	0.460104

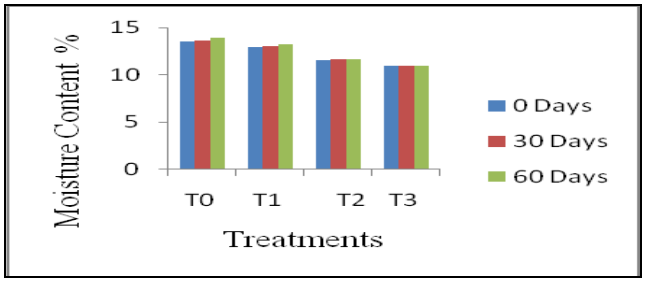

Fig 2 Moisture Content of Extruded fortified corn snack packed in HDPE during storage

CARBOHYDRATE CONTENT

The effect of storage period on the carbohydrate content of extruded fortified corn snack prepared with different proportions of corn meal, oat meal, and whey protein concentrate is presented in Table 3.

The data clearly indicated that there was slight decrease in carbohydrate content of sample T_1, T_2 & T_3 including the control sample T_0. The carbohydrate content of the control sample got highest score than other samples due to the maximum incorporation of corn added to the treatment. The difference in carbohydrates content in the sample may be attributed the presence of major proportion of corn meal. These results are conformity with the scientific literature by Sumathi *et al.*, (2007). The carbohydrate content decreases considerably in different treatments from T_0 to T_3. A significant decrease was also observed in all the treatments from T_0 to T_3 with the increase in shelf life from 0 to 60 days.

Table 3 Carbohydrate Content

S.N0	0 DAYS	30 DAYS	60DAYS
T_0 (%)	56.201	56.055	55.991
T_1 (%)	53.505	53.202	53.001
T_2 (%)	50.487	50.279	50.071
T_3 (%)	48.567	48.401	48.289
f- test	S	S	S
S.Ed.(±)	0.158709	0.198200	0.434396
C.D at (0.05)	0.353923	0.441987	0.968704

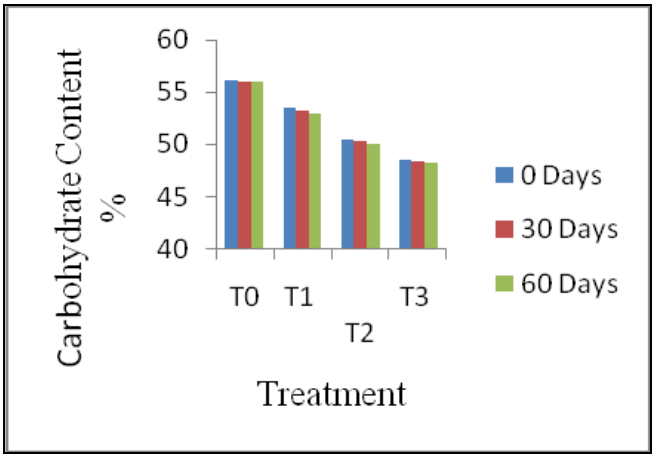

Fig 3 Carbohydrate Content of Extruded Fortified Corn Snack packed in HDPE during storage

PROTEIN CONTENT

The data clearly indicated that there was slight decrease in protein content of sample T_1, T_2 &T_3 including the control sample T_0. The protein content of sample T_3 was got higher than sample T_2 as shown in Table 3.

This is due to in the present study the formulation is based on different treatment on different ratios of whey protein added to the sample. From the ANOVA Table it is evident that the calculated value of F due to treatment is greater than the tabulated value at 5 percent probability level. The protein content increases considerably in different treatments from T_0 to T_3 due to different proportions of whey protein concentrate added to the treatments. A significant decrease was also observed in all the treatments from T_0 to T_3 with the increase in shelf life from 0 to 60 days. Similar findings were cited by Osundahunsi (2006) in scientific literature.

Table 4 Protein Content

S.N0	0 DAYS	30 DAYS	60 DAYS
T_0 (%)	5.760	5.631	5.519
T_1 (%)	6.812	6.791	6.552
T_2 (%)	7.858	7.632	7.510
T_3 (%)	8.293	8.216	8.189
f- test	S	S	S
S.Ed. (±)	0.284823	0.310108	0.128943
C.D at (0.05)	0.635157	0.691542	0.287545

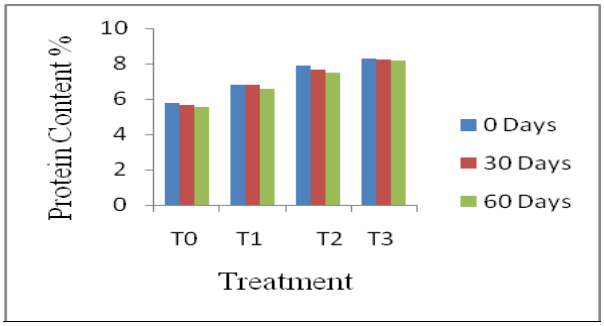

Fig 4 Protein Content of Extruded Fortified Corn Snack packed in HDPE during storage

FAT CONTENT

The decrease in fat content in extruded snack may be attributed to the development of rancidity as a result of lipids hydrolysis that occurs during storage .The fat deterioration during storage may be attributed to activity of lipase enzyme which split off the fat into free fatty acids and glycerol in the presence of catalyst like moisture, light and heat. From the ANOVA Table it is evident that the calculated value of F due to treatment is greater than the tabulated value at 5 percent probability level. Therefore it can be concluded that significant effect of treatment on fat content of T_2 and T_3 sample was observed at interval of 20 days during the storage days. The fat content increases considerably in different treatments from T_0 to T_3 due to different proportions of whey added to the treatments. It was decreased during the storage days. The fat content of experimental sample was found higher than control. A significant decrease was also observed in all the treatments from T_0 to T_3 with the increase in shelf life from 0 to 60 days as shown in Table 5.

Table 5 Fat Content

S.N0	0 DAYS	30 DAYS	60 DAYS
T_0 (%)	14.67	14.09	13.81
T_1 (%)	16.58	16.02	15.85
T_2 (%)	18.36	18.15	17.91
T_3 (%)	20.51	20.44	20.38
f- test	S	S	S
S.Ed. (±)	0.240527	0.290617	0.150963
C.D at (0.05)	0.536377	0.648078	0.336648

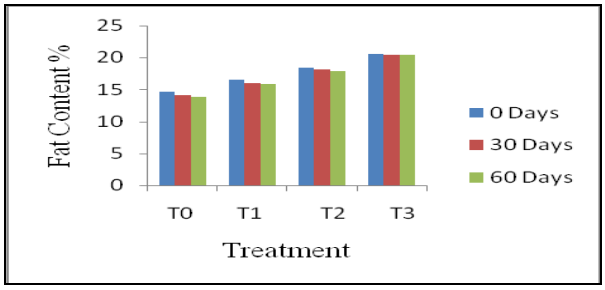

Fig 5 Fat Content of Extruded Fortified Corn Snack packed in HDPE during storage

CRUDE FIBER

The data clearly indicate there was a slight increase in the fiber content of control sample but experimental sample shows the effective reading as compare to the control sample of extruded snack. Treatment sample i.e. (T_1, T_2 & T_3) indicates successful increase in level of crude fiber as shown in Table 6**.** By ANOVA table it is clearly shown that the calculated value due to treatment are greater than the control sample value. Therefore it can be concluded that significant effect of treatment on sample T_1, T_2 & T_3 were observed at interval of 20 days during the storage days.

The crude fiber content increases considerably in different treatments from T_0 to T_3 due to increasing proportions of oat added to the treatments. A significant decrease was also observed in all the treatments from T_2 to T_3 with the increase in shelf life from 0 to 60 days. Similar results were obtained from the scientific literature by Bhattacharya *et al.*, (1994).

Table 6 Crude fiber

S.N0	0 DAYS	30 DAYS	60 DAYS
T_0 (%)	0.416	0.392	0.375
T_1 (%)	0.512	0.468	0.439
T_2 (%)	0.557	0.535	0.512
T_3 (%)	0.601	0.579	0.561
f- test	S	S	S
S.Ed. (±)	0.091067	0.448073	0.291951
C.D at (0.05)	0.20308	0.999204	0.651052

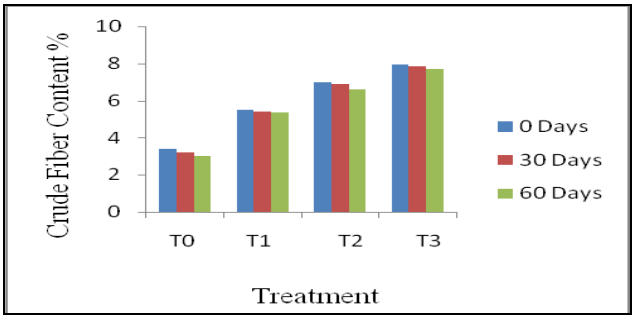

Fig 6 Crude fiber Content of Extruded fortified corn snack packed in HDPE during storage

ASH CONTENT

The ash content increases considerably in different treatments from T_0 to T_3 due to increasing proportions of oat and spinach added to the treatments. A significant decrease was also observed in all the treatments from T_0 to T_3 with the increase in shelf life from 0 to 60 days as indicated in Table 7. Similar results were obtained from the scientific literature by El-Samahy *et al*., (2006 b).

Table 7 Ash Content

S.N0	0 DAYS	30 DAYS	60 DAYS
T_0 (%)	3.393	3.229	3.021
T_1 (%)	5.496	5.399	5.366
T_2 (%)	6.978	6.878	6.618

T_3 (%)	7.933	7.833	7.713
f- test	S	S	S
S.Ed. (±)	0.602073	0.749291	1.600439
C.D at (0.05)	0.269988	0.336005	0.717686

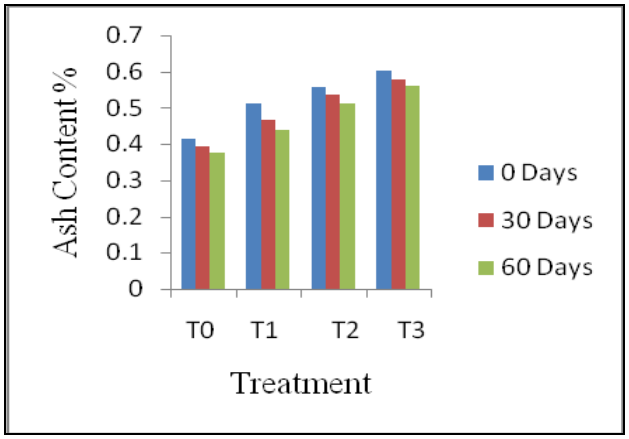

Fig 7 Ash Content of Extruded fortified corn snack packed in HDPE during storage

IRON CONTENT

The iron content increases considerably in different treatments from T_0 to T_3 due to increasing proportions of spinach and oats added to the treatments. A significant decrease was also observed in all the treatments from T_0 to T_3 with the increase in shelf life from 0 to 60 days as shown in Table 8.

Table 8 Iron Content

S.N0	0 DAYS	30 DAYS	60 DAYS
T_0 (%)	2.082	2.059	2.020
T_1 (%)	4.532	4.367	4.213
T_2 (%)	4.867	4.789	4.725
T_3 (%)	5.061	5.032	5.014
f- test	S	S	S
S.Ed. (±)	0.213304	0.432604	0.409699
C.D at (0.05)	0.47567	0.964709	0.91363

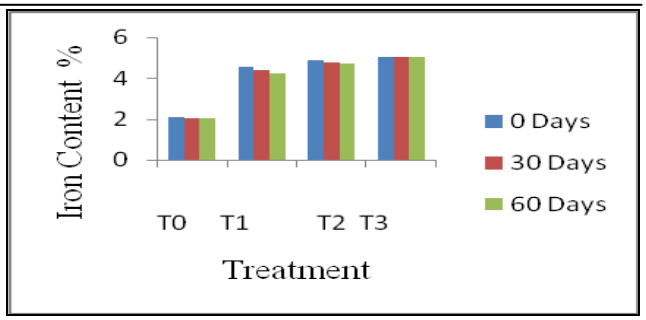

Fig 8 Iron Content of Extruded Fortified Corn Snack packed in HDPE during storage

ASCORBIC ACID

There was increase in variations on the percentage of samples during storage .As the days increase vitamin losses occur in the food product. The vitamin C content increases considerably in different treatments from T_0 to T_3 due to increasing proportions of spinach added to the treatments as shown in Table 9.

Table 9 Ascorbic Acid Content

Treatments	0 Days	30 Days	60 Days
T_0	0	0	0
T_1	3.68	3.58	3.43
T_2	4.05	3.93	3.86
T_3	4.19	4.07	3.98
f- test	S	S	S
S.Ed. (±)	0.207777	0.314251	0.029301
C.D at (0.05)	0.463343	0.71178	0.065343

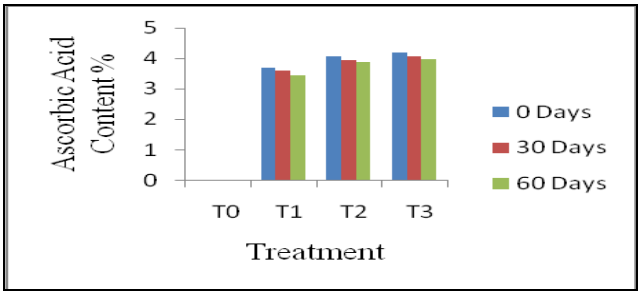

Fig 9 Ascorbic acid Content of Extruded fortified Corn Snack packed in HDPE during storage

Table 10 Sensory Quality Score of Extruded Fortified Corn Snack

Sample No.	Color	Aroma	Taste	Flavor	Overall Acceptability
T_0	8.646	8.644	8.413	8.146	8.410
T_1	6.353	6.213	6.153	6.050	7.543
T_2	7.943	7.743	7.643	7.343	8.866
T_3	5.819	6.510	5.300	5.190	6.716
f- test	S	S	S	S	S
S.Ed(±)	0.01992	0.25182	0.21554	0.40207	0.23576
CD at 0.05	0.044425	0.561516	0.480662	0.896638	0.525752

CONCLUSION

Thus, it can be concluded from the results obtained during the present investigation that good quality extruded fortified corn snack can be prepared by incorporating CM, OM and WPC in different ratios (90:7:3, 80:16:4 and 70:25:5). Physico-chemical and

sensory attributes of the extruded fortified snack was studied for all the treatments. The shelf life analysis was conducted for two months at an interval of 20 days to evaluate best of the sample among all the treatment.

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