RESEARCH PAPER International Journal of Agricultural Engineering | Volume 11 | Sp. Issue | April, 2018 | 1-10
ISSN–0974–2662 ■ Visit us : *www.researchjournal.co.in* ■ DOI: 10.15740/HAS/IJAE/11.Sp. Issue/1-10

Deep fat fried carrot powder incorporated wheat, rice and gram flour based snack food

Krishna Kumar Patel, S.A. Liaquati and Yashwant Kumar Patel

Received : 10.04.2018; **Accepted :** 13.04.2018

See end of the Paper for authors' affiliation

Correspondence to :

Krishna Kumar Patel
Department of Post Harvest Engineering and Technology, Aligarh Muslim University, Aligarh (U.P.) India
Email : k_krishna_374@yahoo.co.in

Abstract : Storage studies of snack foods, developed from the three combinations of cereals (rice and wheat) flour, legume (gram) flour and vegetable (carrot) powder, were conducted in this research. These snack foods were packed in high density polyethylene (HDPE) and aluminum foil (AF) pouches and kept at ambient temperature (28±2°C) and relative humidity (65±2% RH). The shelf life of samples was analyzed on the basis of bio-chemical properties; moisture content (MC), free fatty acids (FFA), peroxide value (PV) and thiobarbutyric acid (TBA) at every 15 days of intervals along with sensorial characteristics for 90 days. The moisture content, FFA, PV and TBA were found to be increased linearly in both pouches during the storage. All parameters, except FFA (R^2>0.62), were found to be correlated strongly (R^2>0.88) with storage periods. The sample packed in AF pouches had superior quality than the samples packed in HDPE pouches. However, no consistent pattern was observed for sensorial characteristics. All samples were found acceptable after 90 days of storage.

Key words : Snacks, Carrot flour, FFA, PV, TBA, Storage

How to cite this paper : Patel, Krishna Kumar, Liaquati, S.A. and Patel, Yashwant Kumar (2018). Deep fat fried carrot powder incorporated wheat, rice and gram flour based snack food. *Internat. J. Agric. Engg.*, **11**(Sp. Issue) : 1-10, **DOI: 10.15740/HAS/IJAE/11.Sp. Issue/1-10.**

Market for nutritious snack foods is on increasing trend across the word with the constantly growing population and international interest in healthy eating. The snack foods are integral parts of diets described as a small quantity of food eaten between meals or in place of a meal. Demands of production of highly nutritious, cost effective and highly acceptable fried snack foods are increasing continuously. The value of snack food industry is about Rs. 100 billion while its worth in terms of volume is over 4,00,000 tonnes according to the ministry of food processing. Snack food generally comprises the bakery products, ready-to-eat mixes, chips, namkeen and other light processed foods, etc. The industry has been growing around 10% for the last three years, while the branded segment is growing around 25% per annum to stand at Rs. 5,000-Rs. 5,500 crore (Biju and Ravindran, 2013).

According to consultancy firm McKinsey and Co, the retail food sector in India is likely to grow from around US$ 70 billion in 2008 to US$ 150 billion by 2025, accounting for a large chunk of the world food industry, which would grow to US$ 400 billion from US$ 175 billion by 2025 (Anonymous, 2010). Though, the Indian snack food market is one of the largest markets in the world, the share of organized sector accounts only half of the market. However, it's expanding at a rate of 20% per annum, the imports, though growing quickly, are still marginal at just US$30 million/annum. Due to high import duties, a complex distribution network and availability of cheaper domestic products. In addition, consumption of commercial savoury snacks in urban is 10 times higher than that in the rural markets (Anonymous, 2008). Around 1000 snack items and 300 types of savouries are sold in India. The segment is largely dominated by potato chips and potato-based products with over 85% share of the salty snack market (Merchant, 2008). In the fiscal year 2016, India exported nearly $ 2.8 million worth of savoury snacks including extruded or expanded products (Sondarva, 2017).

There are wide spectrums of ingredients and formulations for production of a cheaper domestic product and variety of snacks. Wheat or rice flour or oats flour is the principal basis for most fried and baked products (Blandino *et al.,* 2003). According to Mishra *et al.* (2006), the bengal gram flour (*besan*) is a tradition ingredient and reported that the gram flour (*besan*) can be used as a limiting factor for the production of snack foods due to its high cost. Thus, the bengal gram flour (*besan)* can be partially substituted by RF (rice flour) and WF (wheat flour) to overcome the limitation of cost. Similarly, to maintain the nutritional and sensorial qualities of snack foods, CP (carrot powder) can be blended. The technical basis of blending of wheat flour is its low cost, availability and it's (except oat flour) richness in proteins, minerals and vitamins among the cereal flours used as principle basis for the most fried snacks. Wheat flour imparts extensibility, elasticity and strength to the dough. Rice flour resisted oil absorption better (Shih and Daigle, 1999) and develop viscosity between gram and wheat flours. Also, it has some popularity owing to its stability in acidic system. Similarly, carrot powder is best source of an essential nutrient carotene i.e. precursor of vitamin A (Solomons, 2006). This is a combined protein–energy source for maintaining health and preventing vitamin A malnutrition in developing countries. Vitamin 'A' deficiency is a major micronutrient problem among young children and most expensive to ensure adequate intake of vitamin A in the diet. So, to enhance intake of vitamin A, carrot powder can be used in snack foods. Carrot powder also contains oxy-carotenoids such as lutein (Slattery *et al.,* 2000) is very protective agent for colon cancer in men and women (Akubor, 2005). In addition, there is a need to process and preserve carrot like vegetables in the season and incorporate for use in off season

The shelf life of fried snack foods depends, to a large extent, on the quality of the frying medium because significant quantities of the frying medium are absorbed by the food. Later on deterioration of absorbed fat takes place because of hydrolytic reactions and auto oxidation of fat. However, the thermo-oxidative and hydrolytic reactions causes deterioration of fat during the deep fat frying (White, 1991) and forms peroxides, aldehydes and ketones (Bordin *et al.*, 2013). The chemical reactions that occur in oil during frying process are not limited just to thermal oxidation and auto-oxidation, they are more complex (Pedreschi, 2009). In addition to frying, the shelf life of fried products also depends on packaging material, ingredients (Thakur and Arya, 1990) and storage conditions such as light, temperature, relative humidity, etc. These factors are responsible for developing or accelerating the rancidity of fried product which causes off-flavour. The oxidative rancidity is the major problem in fried foods and a cause for the deterioration and unacceptability of food quality (Firestone *et al.*, 1991). Rancidity causes the loss of nutritional quality as well as cause of concern for food safety, as the oxidized fats in a very high dosage have been shown to have toxic effects (Sen and Sen, 1993).Thus the frying medium and packaging material influenced the rate of peroxidation and changes in sensory scores of snacks during storage (Thakur and Arya, 1990). Gray (1978) has reported that the sensory parameters (texture, appearance, smell, taste, etc) of deep fried products depend on the extent of oxidation of fats and oils due to the formation of peroxides, aldehydes, and ketones. Thus, assessing of deep-fried snacks is an important task. The BIS (1989) has recommended the most common tests for assessing the quality of deep-fried snacks. Among them, the moisture, acid-insoluble ash and fat contents, peroxide, and acid values of extracted fat are very important.

In the light of above discussion, the main objective of our research is to investigate some important quality parameters, which indicate the shelf life of deep fat fried snacks.

■ METHODOLOGY

Raw materials preparation :

Multipurpose flours (rice, wheat and gram), spices, salt, vanaspati oil and yellow carrot were purchased from the local market of Aligarh (Utter Pradesh). Blends comprising rice, wheat and gram flour in 1:1:1, 1:1:2 and

1:2:2 ratios were made in order to develop snacks food with the different levels (0 to 15%) of incorporation of carrot powder (Table 1). In order to prepare carrot powder (CP), fresh yellow carrots (better suited for drying) were scrapped to remove the stalks and tips and washed to clean the dust and dirt particles then cut into the slices of 0.5 cm thickness. Sliced carrots were blanched in boiling common salt solution of 2 to 4 per cent strength for 5 minute to inactivate harmful enzymes and then placed over the blotting paper to remove the surface moisture. To dry the carrot slices, slices were loaded on the trays and placed in tray dryer (M/S Khera Instruments Pvt. Ltd., New Delhi) at 60^0C for 11 hour. The dried carrots were unloaded and cooled to room temperature and crushed to small pieces using hammer in muslin cloth. Using the grinder (KenStar, MF0204, India) in Post Harvest Engineering and Technology laboratory, carrot powder was prepared and stored in HDPE pouches. Using Small Scale Sao making machine (Economode Food Equipment Pvt. Ltd, India), all samples of snacks were prepared, fried in open pan and cooled to room temperature before storage (Patel *et al.*, 2013).

Sample selection :

For standardization of flour composition, twenty one samples (Table A) were formulated and conducted sensory evaluation. Samples included for study or excluded were completely based on sensory evaluated by panelist. Hardness, appearance and taste characteristics of samples were the highlighted by panelist. Samples in A-group were completely excluded due to their more hardness while samples in B-group were acceptable but the taste was not upto the mark. More hardness of group-A samples might be due insufficient quantity of gram and wheat flour to counter the gel like character (*i.e.* gel-like gelatinized starch) of rice flour. The amylose content of rice flour affects the quality of bread, including its shape and hardness (Araki *et al.*, 2016). On the other hand the above problem was found almost negligible in group-C samples, from 0 to 7.5 % blend of carrot powder. Sufficient quantities of gram and wheat flour, in group-C samples, countered the unacceptable effect of rice flour. The other samples in group-C, had 10 to 15% carrot powder, were excluded due to unacceptable flavor after frying. Beyond the 7.5 % blend of carrot powder, the unacceptable flavor increased as the level of carrot powder had increased. Samples C1, C2 and C3 were selected for the study named as S_1, S_2, and S_3 found acceptable and rated best by every panelist.

Storage Studies :

All selected samples were packed in two packaging material namely high density polyethylene (HDPE) and aluminum foil (AF) pouches and stored under ambient condition (28±2°C, 65±3% RH). In both packaging materials, air packaging system (APS) was experimented for storage study. Samples were analyzed at 0, 15, 30, 45, 60, 75 and 90 days for their quality.

Quality evaluation :

Proximate composition such as moisture and fat of snack foods were determined according to the procedures of AOAC (1995). Protein content was determined by Khedjahl method (Pearson, 1976). In order to calculate protein content from nitrogen determination, conversion factor used was 6.25. The pH value of the products was determined using Digital pH meter (Indian Make) as discussed by Strange *et al.* (1977). Peroxide value (PV) and free fatty acid (FFA, as Oleic Acid) were analyzed by AOAC (1975). Similarly, thiobarbutyric acid

Table A : Standardization of snack food formulations using cereals, pulses and carrot powder

Sample A		Sample B		Sample C	
Flour ratio (rice : wheat : Bengal gram) 1:1:1	Carrot Powder, %	Flour ratio (rice : wheat : Bengal gram) 1:1:2	Carrot Powder, %	Flour ratio (rice : wheat : Bengal gram) 1:2:2	Carrot Powder, %
A1	0.0	B1	0.0	C1	0.0
A1	2.5	B2	2.5	C2	2.5
A2	5.0	B3	5.0	C3	5.0
A3	7.5	B4	7.5	C4	7.5
A4	10	B5	10.0	C5	10.0
A5	12.5	B6	12.5	C6	12.5
A7	15	B7	15.0	C7	15.0

(TBA) number was measured by the method as described by Strange *et al.* (1977).

Textural analysis :

5-bladed Kramer Shear Cell (HDP/KS5), using 25 kg load cell, heavy duty platform (HDP/90), 2.0 mm/s test speed and 10 mm/s post- test speed was used to measure fracturability of snacks food. The texture analyzer used for the study was TAHD type, Stable Micro System (SMS England), has system of attachment of different type probes for variety of products.

Sensory evaluation :

Sensory evaluation was carried using the procedure outlined by Ranganna (1994). The change in colour, flavour, texture, taste, crispness, buying intention and overall acceptability was determined based on nine-point hedonic scale (9-like extremely, 8-like very much, 7-like moderately, 6-like slightly, 5-neither like nor dislike, 4-dislike slightly, 3-dislike moderately, 2-dislike very much and 1-dislike extremely) after 90 days of storage. Sensory evaluation of products was done by 25 panelist comprising trained (teachers and scientists in the age group 32-56 years) and untrained (students aged between 22-26 years). The panelist evaluated the three deep-fried products packed in HDPE and AF pouches for sensory characteristics at every 15 days interval for three months of storage.

Statistical analysis :

All experiments were carried out in triplicate. Experimental data obtained were statistically analyzed using SPSS software (version 15) to test significance by multivariate analysis for RCBD. Comparisons of the treatment and storage means were done using Duncan's Multiple Range Test.

RESULTS AND DISCUSSION

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

Proximate composition :

The developed snack food had cylindrical shape of 1 mm diameter was based on rice flour, wheat flour, gram flour and carrot powder. Table 1 shows proximate composition of these major ingredients. Gram flour contained higher protein level *i.e.* 21.60%. However, the other ingredients rice flour and wheat flour had lower level of 5.7 and 10.80%, respectively and carrot powder contained lowest protein content, 0.80%. The proximate composition of fried snack foods is also presented in the Table 1. The fat content of snack food was noticed between 28 to 35.0%. The snack food without carrot powder had higher fat content. As carrot powder increased from 0 to 5%, the fat content reduced from 35.15% to 27%. This was might be due to the increasing the CP proportion gave an increase in the bulk density and higher moisture absorption capacity of sample because of hydrophilic carbohydrates presence in CP which release moisture rapidly during the frying and takes less frying time consequently less absorption oil. Similar result has also been reported by Echendu (2004) found that the fat content of snack food decreased with increase in level of CP. Tiwari *et al.* (2011) has reported that as the cereal flour (rice flour) increased (40% to 50%) in composition of snack the fat content was increased from 23.2% to 30.0%. In savory snacks developed by Senthil *et al.* (2002) based on wheat and soya flour, oil content was between 33.57 and 39.75 % is conformity of present finding. In addition, the other proximate composition except protein content was also reduced as level of carrot powder was increased. It was seen that all products had

Table 1 : Proximate compositions of major ingredients and developed products

Samples	Moisture (%)	Fat (%)	Protein (%)	PV	FFA	TBA
Major ingredients						
Rice Flour	9.2±0.25	0.60±0.01	5.7±0.03	nd	nd	nd
Wheat Flour	12.86±0.03	1.20±0.08	10.80±0.25	nd	nd	nd
Gram Flour	8.5±0.01	4.50±0.13	21.6±0.56	nd	nd	nd
Carrot Powder	9.0±11	0.60±0.1	0.80±0.06	nd	nd	nd
Savory snacks						
S_1 (0 % CP)	2.2±0.05	35.0±0.68	13.41±0.06	4.30±0.00	0.34±0.01	0.085±0.005
S_2 (2.5 % CP)	2.0±0.08	33.0±0.22	13.50±0.10	4.17±0.05	0.33±0.005	0.080±0.003
S_3 (5 % CP)	1.5±0.17	28.0±0.89	13.67±0.19	3.72±0.11	0.30±0.00	0.075±0.009

*Values are on dry basis; nd- not detected less than 2.2 % moisture as the most of the moisture was lost during deep fat frying (Senthil *et al.*, 2002). This finding is in agreement with Jean *et al.* (1996) and Kulkarni *et al.* (1994). According to Jean *et al.* (1996), the snack food should have moisture content of less than 5 % to make the product brittle while Kulkarni *et al.* (1994) have reported that the product remained crisp upto 2.8 % moisture content. In savory snacks S_1, S_2 and S_3 protein content was 13.41, 13.50 and 13.67% which is in agreement with the reports of Tiwari *et al.* (2011) for deep fat fried snack prepared from rice and gram flour. This report indicated the protein in snack products between 13.8 to 17.5%. However, present study does not confirm the results provided by Senthil *et al.* (2002) for snack food based on wheat flour and soya flour might be due difference in ingredients. They have reported protein content in developed snack products between 20.75 and 27.50%

Storage studies :

Moisture content :

The Table 2 shows that the moisture content of all deep fat fried savory snack food whether it packed in HDPE pouches or in aluminum foil (AF) pouches increased significantly ($P<0.05$). The samples were found to be absorbed moisture at ambient condition throughout the storage period of 90 days. This increase in moisture content was might be due to the absorption of moisture from the headspace air present packaging materials. In addition, the permeation of outside air into the packaging material was also responsible for increasing of moisture content during storage period. Snack food packed in AF pouches had lower moisture (3.79 -2.93%) content than the snack food packed in HDPE pouches *i.e.* 4.43-3.19% at 90 day of storage. At 90 day of storage, the lowest moisture content (2.93%) was evaluated for the snack food sample S_3 incorporated with 5% CP packed in AF pouches. Moisture absorption for all three samples was linearly correlated (Table 3) with the storage period ($R^2>0.88$) is an agreement to the finding by Tiwari et al (2011). The strongest correlation was noted for the sample had 5% carrot powder packed in AF pouches.

Further, the incorporation of 5% carrot powder in sample packed in HDPE pouches, decreased the mean value (at 90 day of storage) of MC for about 31%, from 3.3 1% (at 0 % CP level) to 2.26 % (at 5% CP level). Similarly, it was decreased about 17 %, from 2.78% (0% CP level) to 2.10 % (at 5% CP level) in the case of AF packaging system. This decrement was found to be statistically significant ($P<0.05$) which is important to maintain the crispness of the snack products. The crispness quality of snack food is desirable. If moisture

Table 2 : Changes in moisture content (%) of deep fat fried savoury snacks during 90 days storage periods

Products	Storage periods (days)								
	0	15	30	45	60	75	90	Mean	Std error
HDPE packed									
S_1	2.2d	2.67cd	2.93c	3.18bc	3.57b	4.17a	4.43a	3.31	0.061
S_2	2.0c	2.19c	2.32c	2.40c	2.80b	3.35a	3.60a	2.67	0.047
S_3	1.5d	1.73d	1.85d	2.20c	2.62b	2.75b	3.19a	2.26	0.044
AF packed									
S_1	2.20d	2.26cd	2.35bc	2.48b	2.86b	3.54a	3.79a	2.78	0.055
S_2	2.00e	2.12de	2.23cd	2.31c	2.68b	3.11a	3.25a	2.53	0.019
S_3	1.50e	1.67de	1.76cd	1.94c	2.37b	2.54b	2.93a	2.10	0.029

*Values followed by same letter are not significant ($p<0.05$)

Table 3 : Regression equations and corresponding regression co-efficient for MC, PV, FFA and TBA

Snack food	Moisture content	R^2	PV	R^2	FFA	R^2	TBA	R^2
HDPE packed								
S_1	y=0.365x+2.246	0.948	y=0.066x+3.611	0.938	y=0.02071x+0.333	0.634	y=0.02142x+0.077	0.950
S_2	y=0.272x+1.851	0.920	y=0.050x+3.515	0.946	y=0.0193x+0.3191	0.762	y=0.0215x+0.068	0.955
S_3	y=0.281x+1.419	0.951	y=0.036x+3.351	0.948	y=0.01786x+0.300	0.869	y=0.022x+0.0612	0.958
AF packed								
S_1	y=0.280x+1.943	0.887	y=0.050x+3.875	0.961	y=0.0189x+0.329	0.627	y=0.0199x+0.0701	0.960
S_2	y=0.221x+1.866	0.954	y=0.042x+3.6065	0.975	y=0.0162x+0.317	0.728	y=0.0200x+0.0663	0.964
S_3	y=0.237x+1.391	0.956	y=0.031x+3.430	0.8983	y=0.0135x+0.307	0.837	y=0.0199x+0.0626	0.963

content of products increased during the storage period, it developed sogginess and ultimately it leads to rejection of product (Taoukis *et al.,* 1988). In addition to this, absorption of moisture content by the snacks food also leads to the quality degradation in terms of hydrolytic rancidity. This type of rancidity results development of off-flavor and issues of some texture like sensory attributes. According to Kartz and Labuza (1981), the product's crispness is lost if excess moisture is absorbed (a_w>0.35-0.50) by the snack foods and as it also gives medium for microbial growth (Labuza and Schmidl, 1985). Thus, the absorption of moisture by the products reduces its shelf life.

Peroxide value :

Peroxides are first compounds formed during oxidation of fats and oil. The peroxide value is one of the most common tests that are used to determine oxidation, sharply. Peroxide value measures the concentration of peroxides and hydro peroxides, formed in the beginning stages of oxidation of fats and oils (Addel and Samiha, 2000) and are used as indicators of lipid oxidation (Gray 1978). Peroxide value increased linearly (Table 3) for all snack products (R^2>0.938) during three month of storage at ambient temperature which is an agreement with the results reported by Tiwari *et al.* (2011). Strongest correlation was noted for sample S_3 which had 5% CP and packed in AF pouches. The rate of per-oxidation was highest (10.27 meq/kg of oil**)** in the sample having no CP and packed in HDPE pouch. However, the lowest value of per-oxidation (6.45 meq/kg of oil**)** was evaluated for the sample with highest per cent (5%) CP and packed in aluminum foil (AF) pouch. But, a significant ($p<0.05$) increase in PV was observed in both packaging materials during the storage periods. This increase in PV value of the products during storage might be due to permeability of oxygen in the packaging materials and moisture content in products. Since, the moisture hydrates trace metal ions which catalyse the auto-oxidation of fats (Lapuza, 1978) and at very high moisture content, the auto-oxidation enhanced due to increased mobility of metal catalysts and swelling of the matrix which exposes new catalytic sites (Thakur and Arya, 1990). Thus, the increase in PV suggests that the peroxides are formed in the oils during storage.

Furthermore, since, the carrot powder has antioxidant properties which slow down the per-oxidation rate of oil during the ambient temperature storage. The incorporation of CP caused the lowering of peroxide value. Thus, the sample with highest percentage of CP incorporation found to have lowest peroxide value in both packaging materials (Table 4). Thus, the incorporation of carrot powder can be used to enhance the shelf life of the deep fat fried food product. Consequently, the synthetic antioxidant such as butylate hydroxy anisole (BHA) and butylate hydroxy toluene (BHT) which have devastating effects such as liver damage and carcinogenesis (Grice, 1986; Wichi, 1988) can be avoided. The need of safer natural antioxidants in foods and other industrial applications can be, thus, achieved by using carotenoid like antioxidant in carrot. In addition, as, samples fried in vanaspati oil developed off-odours at the peroxide value of 22 meq O_2/kg fat (Thakur and Arya. 1990) and as per the BIS (Bureau of Indian Standards, 2000) standards the maximum upper limit for peroxide value is 20 meq/kg in edible oils, these samples were acceptable after 90 days of storage.

Free fatty acid :

Free fatty acid is a measure of the amount of fatty acid chains hydrolyzed off the triglycerides backbone (Satier, 2001). The FFA in the fried savory snacks was

Table 4 : Changes in peroxide value (Meq/Kg of oil) of deep fat fried savoury snacks

Products	Storage periods (days)							Mean	Std error
	0	15	30	45	60	75	90		
HDPE packed									
S_1	4.30f	4.71ef	5.15de	5.95d	7.12c	8.75b	10.27a	6.61	0.159
S_2	3.83f	4.43e	4.92d	5.45d	5.99c	7.3b	8.66a	5.80	0.121
S_3	3.56f	3.92e	4.48d	4.75d	5.15c	5.95b	7.05a	4.98	0.086
AF packed									
S_1	4.30f	4.68e	5.13d	5.75d	6.68c	7.76b	8.85a	6.16	0.120
S_2	3.83f	4.37e	4.65d	5.23d	5.97c	6.86b	7.65a	5.50	0.099
S_3	3.56e	3.86e	4.35d	4.80c	5.13b	5.68b	6.45a	4.83	0.073

*Values followed by same letter are not significant ($p<0.05$)

found to be increased linearly (R^2>0.62) with the storage period (Table 5) which is close conformity to the findings presented by Tiwari et al. (2011). But, the value of R^2 differ to their (R^2>0.93) finding might be due to difference in ingredient as well as in storage periods. This increment in values of FFA at 90 day of storage were found to be significant ($P<0.05$) (Table 6). Similar observations were also reported by Gulla and Waghray (2012) and Kalra *et al*. (1998). This increase in FFA results mainly from secondary degradation products of hydroperoxides rather than due to hydrolysis of triglycerides (Thakur and Arya, 1990). But, according to Camire *et al*. (1990), production of free fatty acid is due to hydrolysis of triglycerides, mainly because of lipase enzymes or non enzymatic at high temperatures. However, the changes in free fatty acids also followed similar pattern as those of the peroxidation rate. The mean value of FFA of snack products was ranged from 0.354±0.005 to 0.40±0.013% and 0.345±0.004 to 0.386±0.012% as oleic acid at 90 days of storage in HDPE and AF pouches, respectively which is in agreement with finding of Thakur and Arya (1990). The author also indicated that the salted snacks remained stable for 360 days when processed in vanaspati oil. Thus, products were found safe at 90 days of storage as FFA value below 1%. Since, it is generally accepted that when FFA% >1 in fried oil, products is not safe for consumption (Erickson and Frey, 1994).

Thio-barbituric acid :

TBA value of all samples increased linearly ($R^2 \geq 0.95$) as the storage period increased (Table 3). This observation is an agreement with the reports of Gulla and Waghray (2012). The effect of storage and packaging material on TBA value of all savoury snacks is presented in Table 6. Table 6 shows that the effect of storage period on TBA of in S_1 (control) sample either packed in HDPE or in AF packaging material was significant during the 90 days of storage. In contrast, TBA of samples S_2 and S_3, packed in AF pouches, initially increased insignificantly. However, after 15 days of storage this increment was found significant in both packaging materials.

The maximum TBA value of snack products was found to be 0.21 mg/kg of malonaldehyde for sample S_1 packed in HDPE pouch while the lowest TBA value was found 0.187 mg/kg of malonaldehyde for S_3 in AF pouches at 90 day of ambient temperature storage might be due to the antioxidant property of carrot powder. Thus,

Table 5 : Change in free fatty acid (As oleic acid %) of deep fat fried savoury snacks

Products	Storage periods (days)								
	0	15	30	45	60	75	90	Mean	Std error
HDPE Packed									
S_1	0.34a	0.35a	0.38a	0.4a	0.43a	0.45a	0.46a	0.400	0.013
S_2	0.32b	0.337b	0.362ab	0.370ab	0.395ab	4.25a	0.430a	0.377	0.009
S_3	0.30c	0.323bc	0.34bc	0.343b	0.36b	0.40a	0.41a	0.354	0.005
AF packed									
S_1	0.340a	0.34a	0.36a	0.38a	0.41a	0.43a	0.44a	0.386	0.012
S_2	0.320b	0.328b	0.345ab	0.365ab	0.390ab	0.400a	0.408a	0.365	0.008
S_3	0.300d	0.317bc	0.33bc	0.35ab	0.37a	0.372a	0.377a	0.345	0.004

*Values followed by same letter are not significant ($p<0.05$)

Table 6 : Changes in thiobarbutyric acid (mg/kg of malonaldehyde) of deep fat fried savoury snacks

Products	Storage periods (days)								
	0	15	30	45	60	75	90	Mean	Std error
HDPE packed									
S_1	0.085f	0.090ef	0.109de	0.117d	0.154c	0.18b	0.210a	0.135	0.003
S_2	0.0848e	0.088e	0.104d	0.108d	0.150c	0.178b	0.207a	0.131	0.001
S_3	0.075f	0.086e	0.098d	0.100d	0.15c	0.176b	0.203a	0.127	0.001
AF packed									
S_1	0.085f	0.09ef	0.10e	0.112d	0.150c	0.175b	0.198a	0.130	0.001
S_2	0.082f	0.085f	0.098e	0.109d	0.143c	0.175b	0.193a	0.126	0.001
S_3	0.078f	0.08f	0.095e	0.105d	0.136c	0.174b	0.187a	0.122	0.001

*Values followed by same letter are not significant ($p<0.05$)

it can be seen that the TBA value of snacks was related to the oxygen permeability of the packaging materials as well as to CP blend. Further, the effect of carrot powder on TBA value was also found to be significant ($p<0.05$) in both packaging materials and thus treatment of carrot power decreased the TBA significantly. This was due to antioxidant property of (Ahmad *et al.*, 2017) carotenoid present in the carrot powder.

Texture of products :

The texture of snacks prepared from blends was affected by the storage periods as well as by the packaging materials (Table 7). The hardness (peak shear force, N) of snack food was found to be increased in both pouches (HDPE and AF) as the storage periods prolonged. This increment was higher in HDPE pouches than the AF pouches might be due to the less infiltration of moisture vapor from outside to inside in AF pouches. Since, the moisture causes degradation of fat and form a gel like products at the surface which increased the hardness of the products. The control sample was found harder (> 52.25N) at 90 days of storage in comparison to CP incorporated samples (<41.53N). The snack products with highest per cent of incorporation of CP had lowest hardness value might be due to the hydrophilic carbohydrates caused low bulk density of carrot powder and anti-oxidant property of carotenoid which retarded the degradation of fat and thus formation of less gel like property on the surface of snacks. Thus, the snack food sample, S_3, with 5% CP packed in AF pouches found lowest value of hardness *i.e.* 29.10N at 90 days of storage at ambient temperature.

Sensory evaluation :

Sensory characteristics in terms of colour, flavour, texture, taste, crispness, buying intention and overall acceptability were evaluated at every 15 days of intervals during the ambient temperature storage. The results obtained at day 0 (Patel *et al.*, 2013) and after 90 days of storage are presented in Table 8. The sensorial characteristics of all samples packed in any packaging system, either in HDPE or in AF, were found to be decreased from 0 to 90 days during the storage. Products have carrot powder (S_2 and S_3) scored acceptable value of sensory characteristics such as colour, flavor, and taste, buying intention and overall acceptability either

Table 7 : Textures of products at day 0 and after 90 days of storage

Products	Texture of products (Positive peak force, N)	
	At day0	At day 90
HDPE packed		
S_1	28.92	68.89
S_2	25.56	41.532
S_3	16.1	37.453
AF packed		
S_1	28.92	52.25
S_2	25.56	38.104
S_3	16.1	29.104

Table 8 : Sensory results for deep-fried snacks at day 0 and after 90 days of storage

Products	Colour	Flavour	Texture	Taste	Crispness	Buying intention	Overall acceptability
Day 0							
S_1	8.1	7.9	7.1	8.5	7.2	7.2	7.8
S_2	8.3	8.5	7.5	8.8	8.0	8.3	8.2
S_3	8.2	8.4	7.4	8.7	7.8	7.8	8.1
After 90 days of storage (packed in HDPE)							
S_1	6.9	6.8	5.8	6.6	6.4	6.1	6.4
S_2	7.6	7.6	6.2	8.0	6.9	7.5	7.3
S_3	7.5	7.5	6.0	7.8	6.8	7.3	7.1
After 90 days of storage (packed in AF)							
S_1	7.1	6.9	6.0	6.7	6.9	6.7	6.7
S_2	7.8	8.0	6.2	8.2	7.2	7.6	7.4
S_3	7.6	7.6	6.1	7.8	7.2	7.4	7.2

packed in HDPE or in AF pouches. Since, according to Chavez-Jauregui *et al.*, 2003, panelist's score of 7 or higher (like moderately) given to the product is considered as sign of acceptability. However, the texture and crispness (except crispness of S_2 and S_3 in AF pouches) of all products were scored unacceptable value. The control sample showed acceptable only in terms of colour when packed in AF pouches. All other sensory qualities of control sample (S_1) were scored unacceptable value either packed in HDPE or in AF pouches and rancid flavour was reported after 90 days of ambient storage. Rancid flavour may corroborated with the increase in FFA (%) during storage (Tiwari *et al.,* 2011). On the other hand, the products (S_2 and S_3) with CP powder were found free from rancid flavour even after 90 days of storage might be due to the degradation of fat into FFA (%) slowed down by the carotenoids presence in the carrot powder that acts as antioxidant.

Conclusion :

The carrot like vegetable can be used to produce nutritious snack food as well as simultaneously can be minimized the losses by utilizing fresh vegetable. This study shows that the shelf life of snack products incorporated with carrot powder was better as compared to control sample. Thus, the oxidative rancidity which is major problem in fried foods and also a major cause deterioration can be reduced by blending of carrot powder. Consequently, the carotenoids present in carrot powder can be used as antioxidant. In addition, AF pouches were found more promising than HDPE pouches for such deep fat fried snacks. This study, therefore, indicates the potentiality of developing such products.

Authors' affiliations:

S.A. Liaquati, Department of Post Harvest Engineering and Technology, Aligarh Muslim University, Aligarh (U.P.) India

Yashwant Kumar Patel, Department of Food Processing and Technology, Bilaspur University, Bilaspur (C.G.) India

■ REFERENCES

Addel, S and Samiha, M. (2000). Effect of the addition of propolis extract as natural antioxidant on the keeping quality of biscuit during storage. *Egyption J. Agric. Res.*, **78**: 1659-1671.

Ahmad, S., Ashraf, K. and Khan, I. (2017). Quality and shelf life of snack food as influenced by Incorporation of High Protein Pulses in Multipurpose Flour. *Food Sci. & Nutri.*, **3** (1) : 1-5.

Akubor, P.I. (2005). Functional properties of soybean-corn-carrot flour blends for cookie production. *J. Food Sci. Technol.*, **42**(4) : 303-307.

Anonymous (2008). Snacks, www.naukrihub.com/india/fmcg/overview/snacks, (accessed on 16 Nov, 2009*)*

Anonymous (2010). Food industry. Rochester Investment Consultancy, (accessed date 23-07-2013) http://www.rochestericpl.com/web/food.html

AOAC (1975). Official methods of Analysis of the Association of Official Analytical Chemistry, 12th Edition DC.

AOAC (1995). Official Methods of Analysis of the Association of Official Analytical Chemists,16th ed., P. Cunniff (Ed.). Association of Official Analytical Chemists Inc., Arlington,Va.

Araki, E., Ashida, K., Aoki, N., Takahashi, M. and Hamada, S. (2016). Characteristics of Rice Flour Suitable for the production of rice flour bread containing gluten and methods of reducing the cost of producing rice flour. *JARQ*, **50** (1) : 23 – 31

Biju, M.K. and Ravindran, R. (2013). A Study on the opinion of customers in the chips industry in Tamil Nadu. *GIIRJ*, **1** (2) : 14-27.

BIS (1989). Potato French fries—Specification. Bureau of Indian Standards, IS: 12569.2.

BIS. (2000). Bakery Product and Analysis, 20-24.

Blandino, Ana, Al-Aseeri, M.E., Pandiella, S.S. and Webb, Colin (2003). Cereal-based fermented foods and beverages. *Food Res. Internat.,* **36**(6):527-543.

Bordin, K., Tomihe, K., Mariana, Kazue, A.K. and Silvia, F.T.C. (2013). Changes in food caused by deep fat frying - A review. *Alan*, **63**(1).

Camire, M.E., Camire, A.L. and Krumhar, K. (1990). Chemical and nutritional changes. *Critical Reviews in Food Sci Nutr.,* **29** : 35-57.

Chavez-Jauregui, R., Cardoso-Santiago, R.A., E Silva, M.E.M.P. and Areas, J.A.G. (2003). Acceptability of snacks produced by the extrusion of the amaranth and blends of chickpea and bovine lung. Internat. *Food Sci. Technol.*, **38** : 795-798.

Echendu, C.A. (2004). Nutrient composition and functional properties of maiz bambara groundnut flour blends. *Nig. J. Nutr. Sci.,* **25** : 18-22.

Erickson, M.D. and Frey, N. (1994). Property-enhanced oils in food application. *Food Technologist*, **48** : 63-68.

Firestone, D., Stier, R.F. and Blumenthal, M.M. (1991).

Regulation of frying fats and oils. *Food Technol*, **45** : 90-94.

Gray, J.I. (1978). Measure of lipid oxidation oxidation, a review. *J. American Oil Chemists Society*, **59** : 117-118.

Grice, H.C. (1986). Safety evaluation of butylated hydroxytoluene (BHT) in the liver, lung and gastrointestinal tract. *Food Chem. Toxicol.*, **24** : 1127-1130.

Gulla, S. and Waghray, K. (2012). Blending of oils: A case study on storage stability and sensory characteristics of a ready to eat extruded snack. *J. Nutri., Ditetics & Food Sci.*, **2**(1).

Jean, I.J., Work, R., Camire, M.E., Briggs, J., Barrett, A.H. and Bushway, A.A. (1996). Selected properties of extruded potato and chicken meat. *J. Food Sci.*, **61** : 783-789.

Kalra, C.L., Sehgal, R.C., Nagender, A., Lal, M. and Berry, S.K. (1998). Preparation, quality standards and storage of Mathi- A traditional savoury product. *J.Food Sci. Technol.*, **35**(1):25-29.

Kartz, E.E. and Labuza, T.P. (1981). Effect of moisture activity of sensory crispness and mechanical deformation of snack food products. *J. Food Sci.*, 46 : 403-409.

Kulkarni, S.G., Manan, J.K. and Shukla, I. C. (1994). Studies on Deep –fat fried sevian made from Rice Flour and colocasia. *J. Food Sci. Technol.*, **31**(3) : 207-210.

Labuza, T.P. and Schmidl, M.K. (1985). Shelf-life of food products. *Food Technologist*, **39**(9) : 57-62, 64.

Lapuza, T.P. (1978). Moisture Relation of Foods by Duckworth RB, (Fd) Academic Press, London, 445.

Merchant, A. (2008). India: food processing industry. Complied by Swiss business hub India, p1-15.

Mishra, M., Singh, G. and Kumbhar, B.K. (2006). 20 beverage. Beverage and Food World Journal.

Patel, K.K., Liaquati, S.A., Khan, M.A. and Minz, P.S. (2013). Effect of carrot powder on quality of multipurpose flour based snack food. *J. Agric. Engg.*, **50**(1):27-33.

Pearson, D. (1976). *Chemical analysis of foods*. 7th Ed., London, Church Hill Livingstone 488-497. Specifications for Foods. Vol. **1**, Toronto, Canada.

Pedreschi, F. (2009). Fried and dehydrated potato products, Advances in Potato Chemistry and Technology, pp. 319-337

Ranganna, S. (1994). Handbook of Analysis and Quality Control for Fruits and Vegetable Products. II Edn. Chapter 19: Sensory Evaluation. Tata Mc Graw-Hill Publishing Co. N. Delhi.

Satier, R.F. (2001). The measurement of frying oil quality and authenticity; chapter in Frying: improving quality; book edited by Barry Rossell, Woodhead Publishing Limitaed & CRC Press LLC, p179.

Sen, S. and Sen, D.P. (1993). Oxidised fatty acid content of heat damaged frying oils and Indian deep fat fried products. J Oil Technologist Association India, 89-91.

Senthil, A., and Ravi, R. Bhat, K.K. and Seethalakshmi, M.K. (2002). Studies on quality of fried snacks based on blends of wheat flour and soya flour. *Food Quality & Preference*, **13** : 267-273.

Shih, F. and Daigle, K. (1999). Oil uptake properties of fried batters from rice flour. *J. Agric. Food Chem.*, **47** (4) : 1611–1615.

Slattery, M.L., Banson, J., Curtin, K., Schaeffer, D. and Potter, J.D. (2000). Carotenoid and colon cancer. *Am. J. Clin. Nutr.*, 71, 575-585.

Solomons, N.W. (2006). Vitamin A. In: Bowman B, Russell R, eds. Present Knowledge in Nutrition. 9th ed. Washington, DC: International Life Sciences Institute, 157-83.

Sondarva, T. (2017). The Savoury Snacks Market in India: A Thousand Billion Businesses. http://fmtmagazine.in, (accessed date, February 05, 2018).

Strange, E.D., Benedit, R.C., Smith, J.L. and Swift, C.E. (1977). Evaluation of rapid test for monitoring alterations in meat quality during storage. *J. Food Protect*, **40** (12) : 843-847.

Taoukis, P.S., Elmeskine, A. and Labuza, T.P. (1998). Moisture transfer and shelf-life of packaged foods. In J. H. Hotchkiss (Ed.), Food and packaging interactions. *ACS* symposium, Series no. 365, *19*, 243-261.

Thakur, B.R. and Arya, S.S. (1990). Packaging requirement and stability of fried wheat snacks (Trisnacks). *J. Fd. Si. Technol.*, **27**(2) : 76-81.

Tiwari, U., Gunasekaran, M., Jaganmohan R., Alagusundaram, K. and Tiwari, B.K. (2011). Quality characteristics and shelf life studies of deep-fried snack prepared from rice brockens and legumes by-product. *Food Bioprocess Technol*, **4** : 1172-1178.

White, P.J. (1991). Methods for measuring changes in deep-fat frying oils. *Food Technol.*, **45** (2) : 75–80

Wichi, H.P. (1988). Enhanced tumor development by butylated hydroxyanisole (BHA) from the prospective of effect on forestomach and oesophageal squamous epithelium. *Food Chem. Toxicol.*, **26** : 717-723.