The Andhra Agric. J 65 (2): , 2018

Development and Characterization of Carrot Extruded Product

W Bukkewad Balaji, J Praneeth, J Samuel and Kamlesh Prasad
Department of Food Engineering and Technology, Sant Longowal Institute of Engineering and Technology, Sangrur, Punjab, India

ABSTRACT

Carrot (*Daucus*carrota) is rich in bioactive compounds like beta-carotene, which is precursor of vitamin A. The supplementation of â-carotene enriched pomace powder in food can fulfil the need towards recommended dietary allowance for vitamin A. Extrusion cooked product is commonly treated in the category of junk food. Addition of fiber rich material having enhanced level of â-carotene in form of dehydrated pomace powder in the mixture of extrusion certainly improves the nutritional aspects of extrudates. Juice extraction behaviour is affected by exerted pressure in hydraulic press. The juice recovery was found to more than 80% under pressure at 140.614×10^4 kg/m^2 in comparison to less juice recovery in traditional or enzymatically treated methods are reported elsewhere. The pomace recovered using hydraulic press was also found to be of nutritionally better than other methods of juice extraction. The dehydrated carrot powder could suitably be used in acceptable extruded product preparation with the maximum lateral expansion at a level of 272% and having an overall acceptability level of 8.45±0.21 on sensory 9 point hedonic scale.

Key Words: *Carrot, ß-carotene, extrudate, carrot powder*

Carrot (*Daucus*carrota) is rich in bioactive compounds like beta-carotene, which is precursor of vitamin-A. Also contains anthocyanins, minerals, other phytochemicals and dietary fiber (Sharma *et al*., 2011). It is converted into nutritionally rich processed product such as juice concentrate, dried powder, canned, preserve, candy, pickle, halva, gazrella etc (Kalra *et al*., 1987). Carrot as under the category of perishable vegetable shows significant wastage due to improper harvesting, handling, storage and transportation.

Pomace being the by-product obtained after juice extraction of carrot is nutritionally rich in dietary fiber with beta-carotene (Negi *et al*., 2000). The juice recovery of carrot has been reported to be in the range of 60-70% and loss of carotene in pomace was found to be around 80% with residue which is termed as pomace. Total carotene content of freshly harvested carrot may contain â-carotene around 150 mg per 100 gm. Higher quantity of â-carotene in pomace may help in supplementation of processed product like cake, bread, biscuits, extrudate for enhancing the functionality of food product. The supplementation of â-carotene enriched pomace powder in food can fulfil the need towards recommended dietary allowance for vitamin A (Baloch*et al.,* 1999).

Dehydration of carrot was usually done in earlier days under the sun but this technique adds contaminants. Different dehydration methods of carrot have been performed to increase shelf life, product diversity, and reduction in volume (Mudahar*et al.,* 1992). The temperature and storage condition for dehydrated product was also studied to see the affect browning of the product.

Extrusion cooking is an important and popular food processing technique classified as a high temperature-short time process which generally lack in fibrous materials. This product is also treated in the category of junk food. It is very useful from the standpoint of nutritional value as nutrient losses are low than other thermal processing methods (Moscicki*et al*., 2003). Extrusion cooking technology being used increasingly in the food industries for the development of new products, such as cereal-based snacks including dietary fiber, baby foods, and breakfast cereals and modified starch from cereals (Sebio and Chang, 2000). The objective of this study was the standardize the process of carrot powder preparation, develop and characterize carrot based â-carotene rich extruded snack product by using twin screw extruder.

MATERIAL AND METHODS

Carrots *(Daucuscarota)*, rice flour, corn flour, and chick pea flour were procured from the local market of Longowal, Punjab, India. The chemicals used in present investigation were of analytical reagent (AR) grade.

Extraction characteristics of carrot Juicer extraction

Juice extraction of whole carrot with variable maturity group was carried out using juicer mixer grinder (Sujata, Pvt.Ltd, New Delhi).

Hydraulic pressing

Hydraulic press was used to study the effect of pressure on the pomace recovery and total solid content in the pomace. The shreds obtained during sample preparation were processed through hydraulic press at different pressure varying from 14.061×10^4 kg/square meter to 140.614×10^4 kg/square meter.

Determination pomace recovery

The pomace remained after the juice extraction using hydraulic press was calculated for each pressure applied, using following equation

$$\text{Pomace recovery (\%)} = \frac{\text{Pomace weight}}{\text{Carrot weight}} \times 100 \quad \text{———(1)}$$

Determination of juice recovery

The juice was expressed by using hydraulic press and Juice recovery was calculated by following equation

Juice recovery(%)

$$= \frac{\text{Carrot weight} - \text{pomace weight}}{\text{Carrot weight}} \times 100 \quad \text{——(2)}$$

Determination total solid in pomace

Total solid in pomace is calculated by using following equation

Total solid in pomace (%)

$$= \frac{\text{Dehydrated pomace weight}}{\text{Carrot weight}} \times 100 \quad \text{———(3)}$$

Particle size distribution

The carrot shreds hydraulic pressed and without pressed were dried in cabinet drier for 8 hours at 65±2ÚC. Size reduction was carried out for carrot without pressed and pressed dehydrated shreds by using juicer mixer grinder (Sujata Pvt Ltd, New Delhi). Particle size distribution of carrot pomace powder was carried out using sieve analysis technique. The sieve number 25, 44, 60, 100 and 240 BSS were used for particle size distribution.

Development of fiber rich extruded Extrusion process

Extrusions of samples were performed using a co-rotating twin-screw extruder (Basic Technology Pvt. Ltd. Kolkata, India) with capacity of 7.5 HP motor (400 V, 3 phases, 50 cycles).

Physico-chemical analysis

Lateral expansion

The ratio of diameter of extrudate and the diameter of die was used to express the expansion of extrudate (Ainsworth, 2006; Juvvi et al., 2012). Lateral expansion (LE, %) was then calculated using the mean of the measured diameters:

$$LE = \frac{\text{(diameter of product - diameter of die hole)}}{\text{diameter of die hole}} X100$$

Bulk density

Bulk density (g/cm^3) was calculated according to the method of (Stojceska *et.al*., 2008).

$$BD = \frac{4\,m}{\pi d^2 L}$$

Where

m is mass (g) of a length L (cm) of extrudate with diameter d (cm).

Water absorption index (WAI) and water solubility index (WSI)

WAI and WSI were determined according to the method developed for cereal**s** (Stojceska,V. *et.al*., 2008; Juvvi et al., 2012).

$$\text{WAI (g/g)} = \frac{\text{Weight gain by gel}}{\text{Dry weight of extrudate}}$$

$$\text{WSI(\%)} = \frac{\text{Weight of dry solid in supernatent}}{\text{Dry weight of extrudate}} X100$$

Hardness of extrudates

Texture analyzer (TA – XT2, Stable Micro Systems Ltd., Godalming, UK) equipped with a 500 kg load cell. An extrudate 40 mm long was compressed with a probe SMS – P/75 – 75mm diameter at a crosshead speed 5 mm/sec to 3 mm of 90% of diameter of the extrudate (Stojceska.V et.al. 2008).

Data analysis

Experiments were carried out in triplicates, values represented as average with standard deviation from the experiments. The statistical calculations were performed using Microsoft Excel 2000.

Sensory analysis

The samples were sensory evaluated for overall acceptability of extrudate using 9 point hedonic rating scale by semi-trained panel of the Department of Food Engineering and Technology, Sant Longowal Institute of Engineering and Technology, Longowal.

RESULTS AND DISCUSSION

Pomace recovery

The hydraulic pressure affects the solid content of the carrot, while extraction of pomace. The pomace recovery was found to be varying from 27.17±0.60% at pressure $14.062\times10^4$to 17.67±1.73 % at pressure 140.614×10^4 kg/m^2 (Table 4.4). A pressure of 14.062×10^4 to 140.614×10^4 kg/m^2 (maximum capacity permissible with available press machine) was applied which resulted in juice recovery up to 83.4 %. The color of the juice was observed visually at pressure 140.614×10^4kg/m^2, little turbid, because most of the percentage of carotenoid and soluble solid were lost. Unlike, 28.123×10^4 kg/m^2 load applied which resulted in juice recovery 73 % and that was due to incomplete cell disintegration of the carrot. Moreover, in hydraulic pressing the carotenoid remains in the carrot cell.

Development of Extrudate

Extrudate were prepared using rice flour, corn flour, and chickpea flour supplemented with fractionated pressed and un-pressed carrot powder in different concentration at constant temperature, feed moisture, and feed rate. Carrot powder was used in varying level from 1 to 5% in making the extruded product.

Lateral expansion

From Table 1.2 depicts highest value for the lateral expansion was found to be 272% (100 BSS, 1% without pressed carrot). The lowest value of lateral expansion was found to be 211.11 % (44 BSS, 5 % without pressed carrot). Starch, the main component of cereals played major role in expansion process (Kokini*et al*., 1992). Increasing level of carrot pomace powder resulted decrease in expansion of pressed carrot pomace extrudate due to the dilution effect of pomace on starch, and is in agreement with the work of (Altan *et al*., 2008). By comparing both results (Fig. 1a and b), it was clear that lateral expansion was higher for extrudates made from pressed carrot pomace powder than that of raw carrot powder extrudates because raw carrot powder has higher moisture and high soluble components. Because moisture has negative effect on lateral expansion index of extrudates. (Ding *et al.,* 2005; kothakota *et al*., 2013)

Water absorption index and Water solubility index

The water absorption index ranged from 8.54 gm/gm (60 BSS, 3% without pressed carrot) to 5.85 gm/gm (25 BSS, 4 % without pressed carrot) for the extrudates. WAI of the extrudates increases with decrease in particle size of pomace powder, due to competition of absorption of water between pomace and available starch (Altan *et al*., 2008), also increases pomace percentage and decreases particles size of pomace powder were affecting gelatinization (observed in Fig.3 a and b), it was one of the most important effect in starch extrusion component of foods. Feed moisture was found to exert the greatest effect on gelatinization (Altan *et al*., 2008: kothakota *et al.,* 2013).

The higher and lower value for the water solubility index found to be 15.50% (60 BSS 2% pressed carrot pomace) and 4.75% (25 BSS 2% pressed carrot pomace) for extrudates (observed in fig 4a and b). WSI was increased with increasing pomace percentage in carrot pomace powder extrudate as compare to raw carrot powder extrudates. Similar findings have been reported by Altan *et al*., (2008) in barley flour and tomato pomace extrudates. WSI is a parameter that reflects the degradation suffered by the components of the fiber (kothakota *et al.,* 2013). Carrot pomace was high in fiber content which disrupts continuous structure of the melt in extruder, impeding elastic deformation during extrusion (Moraru and Kokini, 2003).

Hardness

Hardness of the extrudate ranged between 8.98 to 19.90 N for raw carrot pomace extrudates and 8.76 to 17.49 N for pressed carrot pomace

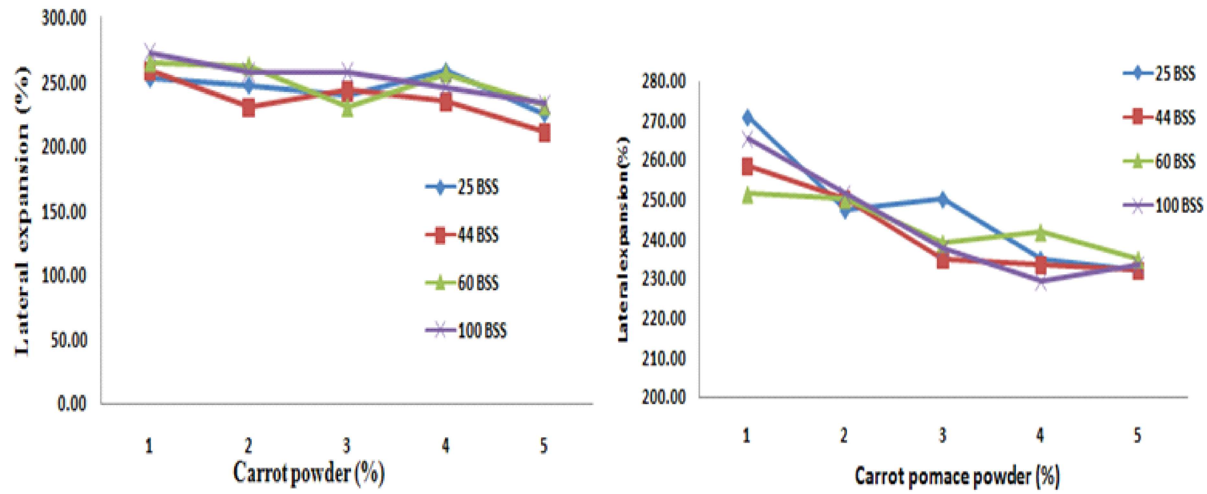


Fig. 1 (a) Effect of concentration of raw carrot powder and (b) carrot pomace powder on lateral expansion of extrudate

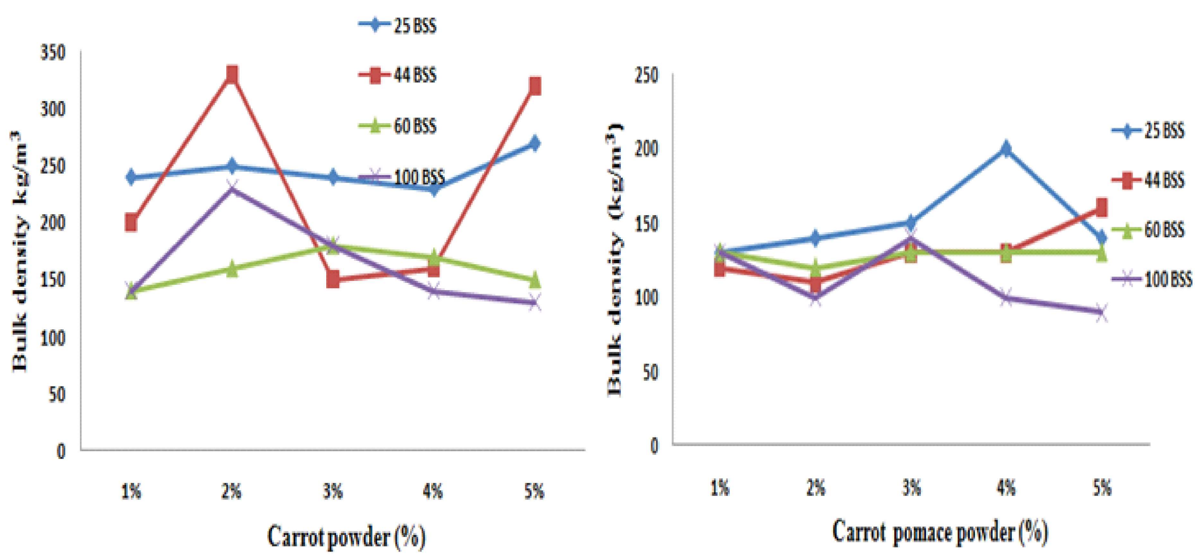


Fig. 2 (a) Effect of concentration of raw carrot powder and (b) carrot pomace powder on Bulk density of extrudate.

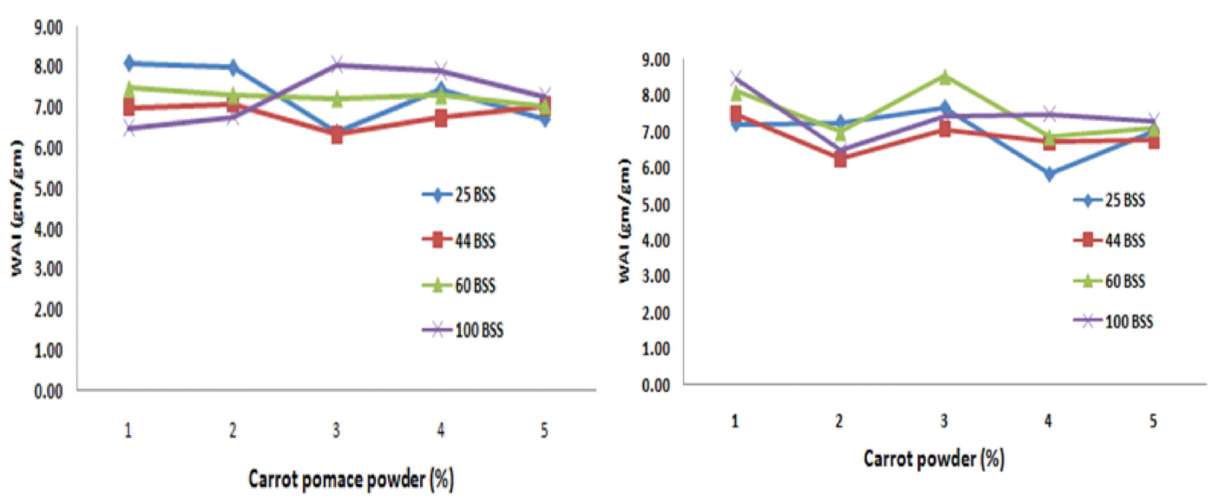
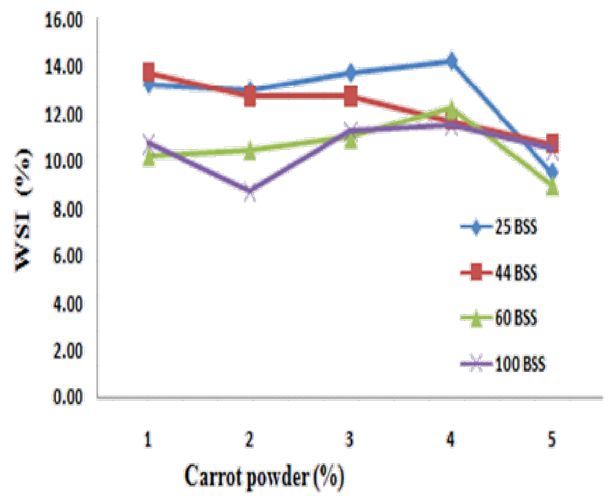


Fig. 3 (a) Effect of concentration of raw carrot powder and (b) carrot pomace powder on Water absorption index of extrudate



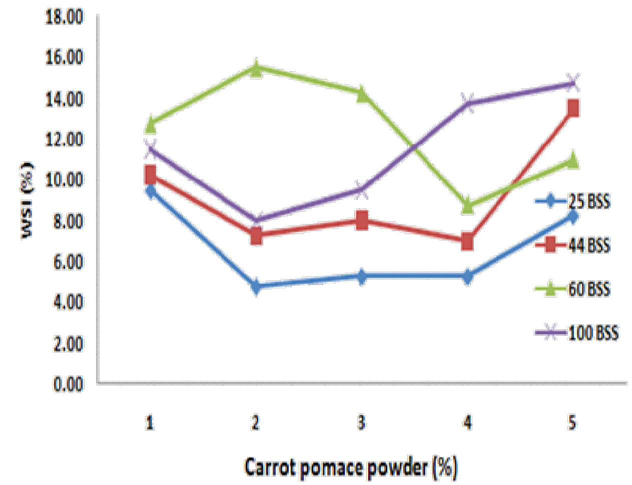


Fig. 4 (a) Effect of concentration of raw carrot powder and (b) carrot pomace powder on Water solubility index of extrudate.

Table. 1 Effect of particle size on hardness of carrot based extrudate at different concentrations

Raw material	Sieve no (BSS)	Hardness				
		1%	2%	3%	4%	5%
Raw carrot powder	25	11.89±2.82	13.68±1.01	11.73±2.29	13.02±0.59	17.13±1.35
	44	9.97±0.30	10.64±0.55	12.01±1.61	9.14±0.88	16.49±3.02
	60	10.74±1.61	11.78±2.38	10.84±0.89	10.56±1.25	13.04±1.23
	100	11.35±3.31	11.26±0.44	12.41±2.33	8.76±1.65	11.84±1.22
Carrot pomace Pressed	25	8.98±1.69	11.68±1.27	9.01±1.36	12.74±2.15	17.49±2.85
	44	11.64±1.26	18.20±1.55	12.17±4.69	9.83±1.12	19.90±0.72
	60	10.80±1.99	12.70±3.26	13.67±0.96	18.96±1.06	18.30±1.37
	100	12.48±0.62	10.82±0.61	11.11±1.79	10.77±1.66	14.55±3.36

Table. 2 Sensory chart for raw carrot powder and Carrot pomace powder enriched extrudate

Raw material	Mesh no	powder%	Color	Taste	Texture	Mouth feel	OAA
Raw carrot powder	25	1	8.1	8.2	8.2	8.3	8.20±0.08
		2	7.9	8	7.9	8.0	7.95±0.06
		3	7.6	7.6	7.6	7.9	7.68±0.15
		4	6.9	7.2	7.1	7.7	7.23±0.34
		5	6.3	6.9	7.0	7.1	6.83±0.36
	44	1	8.0	8.1	7.9	8.2	8.05±0.13
		2	7.8	7.8	7.4	8.0	7.75±0.25
		3	7.4	7.3	7.2	7.8	7.43±0.26
		4	7	7.0	7.0	7.3	7.08±0.15
		5	6.8	6.5	6.4	6.4	6.53±0.19
	60	1	7.9	8.0	7.7	7.9	7.88±0.13
		2	7.6	7.8	7.4	7.5	7.58±0.17
		3	7.3	7.6	7.0	7.2	7.28±0.25
		4	7	7.0	6.5	6.6	6.78±0.26
		5	6.8	6.8	6.0	6.2	6.45±0.41
	100	1	7.5	7.7	7.2	7.0	7.35±0.31
		2	7.2	7.1	6.9	6.5	6.93±0.31
		3	7	6.7	6.2	6.2	6.53±0.39
		4	6.7	6.2	6.0	6.0	6.23±0.33
		5	6.2	6.0	5.0	5.0	5.55±0.64
Carrot pomace powder	25	1	8.4	8.5	8.7	8.2	8.45±0.21
		2	8.1	7.6	7.9	7.8	7.85±0.21
		3	7.5	7.4	7.7	7.7	7.58±0.15
		4	6.9	7.0	7.1	7.2	7.05±0.13
		5	6.4	7.2	6.4	7.0	6.75±0.41
	44	1	8.1	8.4	8.6	7.9	8.25±0.31
		2	8	7.9	7.8	7.6	7.83±0.17
		3	7.8	7.6	7.9	7.4	7.68±0.22
		4	7.2	7.0	6.8	7.1	7.03±0.17
		5	6.6	7.0	6.2	7.1	6.73±0.41
	60	1	8.2	8.2	7.9	8.1	8.10±0.14
		2	7.9	7.8	8.0	7.7	7.85±0.13
		3	7.4	7.5	7.1	6.9	7.23±0.28
		4	7.0	7.2	7.1	6.8	7.03±0.17
		5	6.2	6.8	6.7	6.5	6.55±0.26
	100	1	8.0	7.9	8.1	7.8	7.95±0.13
		2	7.6	7.3	7.3	7.2	7.35±0.17
		3	7.1	7.0	6.9	7.0	7.00±0.08
		4	6.6	6.7	6.5	7.0	6.70±0.22
		5	6.3	6.5	6.4	6.7	6.48±0.17

extrudates. The hardness increased with increasing carrot pomace percentage in both extrudates samples. Effect of feed composition indicates that the highest carrot pomace content causes less crispy extrudate. This might be the result of the effect of fiber in the carrot pomace (observed in Table 1). Fiber reduces the cell size, probably by causing premature rupture of gas cells, which reduces the overall expansion and results in less porous structure (Yilbas*et al.,* 2003 and Altan *et al.,* 2008).

Sensory characteristics of extrudate

Sensory evaluation of the prepared extruded product was carried out using 9- Point hedonic rating scale. The parameter like taste, texture, color, mouth-feel and overall acceptability (OAA) were considered for the sensory analysis (Table. 2). The overall acceptability score was found in the range of 5.5 to 8.2 for the use of raw carrot powder and 6.5 to 8.45 for the use of carrot pomace powder. The highest value of overall acceptability score was found on the use of 1% level of 25 BSS pressed carrot powder with the score of 8.45±0.21 (Table. 2) with highest expansion ratio as 270.83, which is considered as best among the prepared extrudates.The level carrot pomace powder (25 BSS) fraction was maintained as 1% for the preparation of extruded product in bulk (Plate 4.7) to be subjected for sensory analysis through larger panel of semi-trained member on the basis of overall acceptability and was found to be 8.27±0.47.

Conclusion

It was concluded that acceptable extrudates rich in â carotene having overall acceptability score of 8.45, which could be prepared using carrot pomace powder 1%. Increase in the level of carrot pomace powder with increase in bulk density of extrudates. The Water absorption index (WAI) of the extrudates increases with decreased particle size of carrot pomace powder whereas, Water solubility index (WSI) increases with increase in pomace percentage in carrot pomace powder extrudate. This extrusion cooking data can help predict the expected performance of extruded material in investigations of the potential use of rice flour mixed with other cereal flours in the improvement of nutritional quality of products.

LITERATURE CITED

Altan A, Mc carthy K Land Maskan M 2008 Extrusion cooking of barley flour and process parameter optimization by using response surface methodology. *Journal of Science of Food and Agriculture,* 88: 1648-1659.

Ainsworth P, Senolibanog lu, Emir Ayse Ozer and Andrew P 2006 Physical and sensory evaluation of a nutritionally balanced gluten free extruded snack. *Journal of Food Engineering,* 75: 469-472.

Baloch A K, Buckle, K A and Edwards R A 1997 Effect of Processing Variables on the Quality of dehydrated Carrot, leaching losses and Carotenoid Content. *Journal of Food Technology,* 12: 285-293.

Ding Q, Ainsworth P, Gregory T and Hayley M 2005 The effect of extrusion conditions on the physicochemical properties and sensory characteristics of rice-based expanded snacks. *Journal of Food Engineering,* 66:283-289

Kalra C L, Kulkarni S G, and Berry S K 1987 The carrot a Most Popular Root Vegetable. *Indian Food Packer,* 46-72

Kokini J, Chang C and Karwe M 1992 *Food Extrusion Science and Technology*. Marcel Dekker Inc. New York, USA.

Kothakota A, Navdeep J and Thimmaiah B 2013 A study on evaluation and characterization of extruded product by using various by-products. *African Journal of Food Science, 7 (12)*

Moscicki L, Koz³owska H, Pokorny J and Zuilichem D 2003 Expander cooking of rapeseed faba beans mixture. *Agricultural Engineering*, 6 (2)

Mudahar G S, Buhr R J and Jen J J 1992 Infiltrated biopolymers effect on quality of dehydrated carrots. *Journal of Food Science,* 57:526–529

Negi P S and Roy S K 2000 Effect of low cost storage and packaging on quality and nutritive Value of fresh and dehydrated carrots. *Journal of the Science of Food Agriculture*, 80(15):2169-2175

Sharma K D 2010 Chemical composition, functional properties and processing of carrot-a review. *Journal of Food Science and Technology*, 310-317.

Sebio L and Chang Y K 2000 Effects of selected process parameters in extrusion of yam flour on physicochemical properties of extrudates. *Nahrung*, 44: 96–101

Stojceska V, Ainsworth P, Andrew P, Esra I, and Senol I 2008 Cauliflower by-products as a new source of dietary fibre, antioxidants and proteins in cereal based ready-to-eat expanded snacks. *Journal of Food Engineering*, 87:554-563.

Yilbas B S, Hussain M M and Dincer I 2003 Heat and moisture diffusion in slab