Effects of Various Packaging Materials on Physico-chemical Characteristics of Vacuum Fried Carrot Chips During Storage

ABSTRACT

Aims: The objective of this study was to determine the effects of type of packaging materials and time of storage on the physicochemical characteristics of vacuum fried carrot chips

Place and Duration of Study: The research work was carried out at the Dept. of Processing and Food Engineering (P&FE), Kelappaji College of Agricultural Engineering and Technology, Tavanur, Kerala during the year of 2019-20.

Methodology: The vacuum fried carrot chips were packed into three different packaging materials namely low-density polyethylene stand pouch (LDPE), laminated aluminum flexible pouch and polypropylene. All three packaging materials were tested with and without N_2 gas filling. The storage studies were conducted for the vacuum fried carrot chips which was fried under optimized processing conditions: Frying Temperature-100°C; Frying Pressure-13 kPa; and Frying Time- 20 min. The experimental study was conducted for 4 months period and data was recorded for every 30 days interval.The packed samples were stored at the ambient temperature (25±5ºC) and relative humidity (70±10%) for storage studies. The quality attributes such as moisture content, water activity, oil content, hardness and colour values of the chips were determined during the storage studies.

Results: Based on the research study, the results shown that the oil content remained constant throughout 120 days of storage period in all packaging materials. The water activity, moisture content, hardness and colour values got increased with increase in storage time. The moisture content, water activity and hardness values were less in laminated aluminium pouches with N_2 gas filling compared to polypropylene and LDPE.

Keywords: ***Vacuum frying, carrot chips, Packaging material and Storage period***

1. INTRODUCTION

Vacuum frying is promising technology which uses a very low pressure and temperature rather than atmospheric deep fat frying to improve the quality attributes of food products. In vacuum frying, the food is heated at very low pressure of less than 6 kPa[1].At such reduced pressures, the boiling point as well as smoke point of oil gets reduced. The absence of air during the frying process inhibits oxidation including lipid oxidation and enzymatic browning and thus could retain color and flavor. Vacuum frying offers a minimal change in oil quality and desired organoleptic properties without loss in nutritional value. It is widely used for processing various foods, mostly vegetables and fruits. Vacuum technology reduces the oil content and acrylamide content of fried product preserve the color, texture, flavor and preserve the nutritional compounds[2]. Moreover, oil used in vacuum frying can be reused to several times without affecting its quality thus increasing its economic feasibility. In response to the increasing health concerns of consumers, vacuum frying of fruit and vegetables has been studied as a potential alternative processing method for high quality snack foods[3]. Various factors such as the rate of heating, oil penetration into the food, oil–food interactions and oil degradation affect the texture and final product quality.

Now a days, there is an increasing demand for healthy snacks which provides healthy and nutritious food for consumption to reduce obesity. The production of crispy and crunchy snacks using different frying, freezing, drying and other processing methods enhance the acceptability and consumption of carrot [4]. Carrot chips, with its unique sensory attributes are a popular variety of snacks which is dry and crispy In this regard, carrot chips prepared by vacuum frying could become a popular snack food. Frozen carrots fried in refined palm oil have been found to show good quality[5]. So far, there is a limited availability of ready-to-eat carrots chips in the market.

The main causes for spoilage of fried snack food were moisture absorption, fat rancidity, breakage during handling, and environmental factors such as oxygen, temperature, light and relative humidity[6]. Shelf-life tests must be conducted for critical deterioration factors (chemical, physical and sensory). In this context, the problem of moisture absorption is more serious than that of oxygen exposure. To ensure repeated sales, vacuum fried carrot chips have to be shelf-stable and crisp when customers were consumed. In the processing and storage of vacuum fried carrot chips, proper packaging is important to preserve the quality and storage, which is necessary to enhance the shelf life of the snack foods[7]. The essential function of a packaging material is to protect against water absorption, rancidity, loss of odour and entry of foreign odours, thereby extending the shelf life of the product. The main aim of the study was to determine the effects of type of packaging material and time of storage on the physico-chemical characteristics of vacuum fried carrot chips.

2. MATERIALS AND METHODS

The research work was carried out at the Dept. of Processing and Food Engineering (P&FE), Kelappaji College of Agricultural Engineering and Technology, Tavanur, Kerala.

The research was conducted using a vacuum frying system available in the Department of Processing and Food Engineering, KCAET, Tavanur. Vacuum fryer was a batch type, having a capacity of 3 kg[8].The system consisted of two chambers namely frying chamber and oil storage chamber. The two chambers were made up of stainless steel (SS 316). The frying chamber and oil storage chamber was provided with heaters - two heaters in frying chamber and one in oil storage chamber, respectively. The water ring vacuum pump, cooling tower, compressor, nitrogen cylinder and condenser were also attached to the vacuum frying system. The entire system was controlled by a microprocessor and PID (Proportional Integral Derivative) controller. A de-oiling system was mounted inside the frying chamber with frying basket holder. The orange colour and matured carrot was procured from the local market at Tavanur, Kerala. Carrots were cleaned manually, peeled with peeler and made into strips by using dicer. Based on preliminary studies, the selected average thickness and diameter carrot strips were 4 mm and 39.07 mm respectively. The vacuum frying process involved in different steps *viz.,* sample loading, frying/heating oil, depressurization, frying and de-oiling, pressurization and cooling. Initially the samples were weighed and filled in the frying baskets. The two frying baskets were filled with equal amount (approx. 1050-1100 g each) of samples in order to maintain the balance during deoiling. The carrot samples were fried in 35L of Refined palm oil under processing conditions of frying temperature (100ºC), pressure (13 kPa) and time (20 min). After frying, the product was centrifuged at 1000 rpm for 6 min.

2.1 Experimental design of the study

After completion of frying, the vacuum fried carrot chips were packed under different packages as shown in the Table 1. 200 micron thickness packaging materials were selected for the storage studies [9]. The packaging was done using nitrogen flush packaging machine (Model: QS 400 V, M/s. Sevana packaging solutions, Kerala, India) with 95% of N_2 gas filling[5]. The packed samples were stored at ambient temperature (25±5ºC) and relative humidity (70±10%) during the study period. During storage studies, the changes in the physical and biochemical parameters of vacuum fried carrot chips were analyzed at regular interval of 30 days for 4 months. Triplicates were carried out for the experiment and mean value was taken for the analysis. The obtained results were statistically analysed using the ANOVA Procedure of the statistical package for social science (SPSS 2.0) software. Significant differences ($p<0.01$) were further determined by using Duncan's multiple-range test.

Table 1. Experimental design of the Study

S.No	Packaging Material (Independent parameters)	Dependent Parameters
1	P1- LDPE stand up pouches with (95 %) N_2 gas filling	• Moisture content • Oil content • Water activity • Hardness • Color
2	P2- Laminated aluminum foil flexible pouches with (95 %) N_2 gas filling	
3	P3 - Polypropylene pouches without (95 %) N_2 gas filling.	
4	P4- LDPE stand up pouches without N_2 gas filling	
5	P5- Laminated aluminum foil flexible pouches without N_2 gas filling and	
6	P6 - Polypropylene pouches without N_2 gas filling	

2.2 Physico-chemical analaysis of the chips

Moisture content of vacuum fried carrot chips was studied as per method[10]. The fat content of the chips was determined using AOAC standard procedure [10] with Soxhlet extraction method (M/s.Pelican Equipments, SOCS 06, India). The water activity experiment of the VF Carrot chips was conducted by using water activity meter (M/s. Aqua lab, Decagon Devices Inc., Pullman (Wa), USA) [11]. Hardness of the chips was assessed using Texture analyzer (Stable Micro systems, TA HD Plus) with the cylindrical/ steel ball probe. Test conditions (Mode : Measure Force in Compression, Option : Return to Start, Pre-Test Speed : 1.0 mm s-1, Test Speed : 0.5 mm s-1, Post-Test Speed : 10.0 mm s-1, Probe : ball end probe model with 5 kg load cell). The compression force required to fracture the surface cell structure of carrot chips was obtained using Texture Expert software (Version 3.5.0.).The color of the vacuum chips was determined using a Hunter lab Colorimeter – Color flex EZ diffuse model. This colorimeter expressed the colors on L*, a*, and b*. The L* value represents lightness its ranging from, 0 (blackness) to 100 (whiteness), a* represents +ve (redness) and –ve (greenness) and b* represents +ve 60 (yellowness) and –ve 60 (blueness)[12]. The chips were crushed to granules to obtain uniform colour values. All the experiments were replicated thrice.

3. RESULTS AND DISCUSSION

Packaging and storage studies were performed for the vacuum fried carrot chips. The vacuum fried carrot chips were packed in three different packaging materials *viz.,* low-density polyethylene (LDPE) stand up pouches, laminated aluminium flexible pouches and polypropylene with and without N_2 gas flushing. The selected packaging materials were 200 micron gauge thickness. The quality analysis for the chips fried under optimized processing conditions of Frying temperature-100°C Frying Pressure-13 kPa and Frying time- 20 min packed under various packaging materials. The experimental study was conducted for 4 months period and data was recorded for every 30 days interval.The symbolic representation of packaging materials was shown in the Table 2. The packed samples were stored at ambient temperature (25±5ºC) and relative humidity (70±10%) for storage studies.

Table 2 : Symbolic representation of packaging materials

S.No	Notations	Details of packaging materials
1	P_{11}	LDPE stand up pouches with (95 %) N_2 gas filling

2	P_{12}	Laminated aluminum foil flexible pouches with (95 %) N_2 gas filling
3	P_{13}	Polypropylene pouches without (95 %) N_2 gas filling.
4	P_{14}	LDPE stand up pouches without N_2 gas filling
5	P_{15}	Laminated aluminum foil flexible pouches without N_2 gas filling and
6	P_{16}	Polypropylene pouches without N_2 gas filling

3.1 Moisture Content

The effect of changes in the moisture content of VF carrot chips during storage are shown in the Fig .1 From Analysis of variance, it was understood that packaging materials and packaging technologies had a significant effect ($p \leq 0.01$) on moisture content during the storage period at individual level. The moisture content of VF-carrot chips increased significantly during the storage period.

From Fig .1, it was observed that the initial moisture of VF-carrot chips at 0th day for samples packed under various packaging materials/technologies *viz.,* P11, P12, P13, P14, P15 and P16 were 2.42, 2.42, 2.41, 2.41, 2.42 and 2.42% (w.b), respectively. Similarly, the final moisture content of VF-carrot chips, after 120 days of storage for treatments *viz.,* P11, P12, P13, P14, P15 and P16 were 4.38, 4.08, 4.21, 5.02, 4.88 and 4.74%, respectively. The highest moisture content of 5.02% was recorded in LDPE packet without nitrogen gas filling (P14) and lowest moisture content of 4.08 % was observed in the laminated aluminium pouch (P12) with nitrogen gas filling. The moisture content of VF-carrot chips increased significantly with increase in storage days. This might be due to the migration of moisture from the outside atmosphere through packaging materials. Amount of moisture present in the chips, packed inside the pouch depends on the relative humidity of the surroundings. The stored product absorbed moisture from the storage atmosphere and increased the weight gradually[13].The moisture content gained by the sample packed in LDPE pouches was more as compared to laminated aluminium pouch and polypropylene. When comparing moisture content gained by chips packed in different type of packaging material with nitrogen flushing and without nitrogen flushing, the result revealed that increment in moisture gain was maximum in samples packed without nitrogen flushing than with nitrogen flushing. The lesser increase in moisture during storage in nitrogen flushed package was mainly due to the flushing of nitrogen that replaced the oxygen (air) and water vapor from the package.

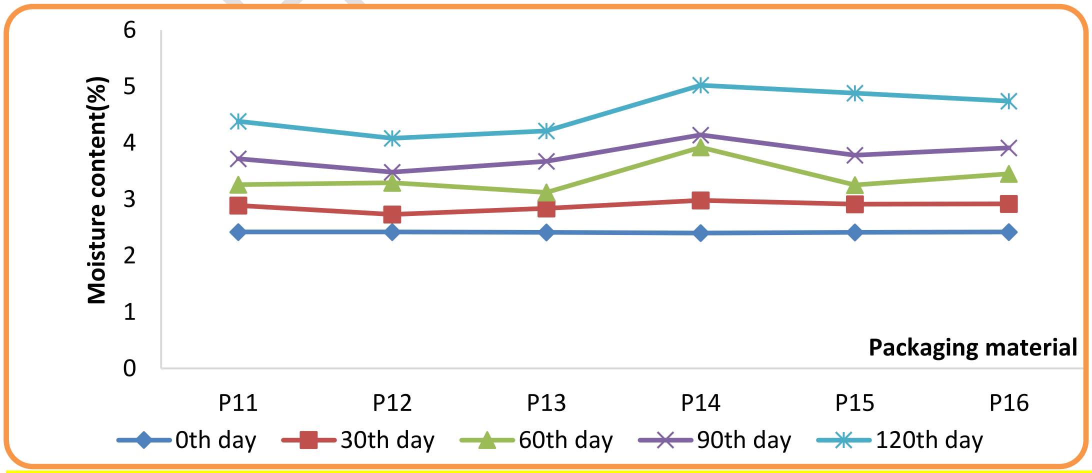

Fig.1. Effect of different packaging materials on moisture content ($p \leq 0.01$) during storage of VF-carrot chips

Ammawath [9] found that the similar results for deep-fat frying of banana chips, LDPE got the highest moisture content and lowest packed using laminated aluminium foil.

3.2 Water activity

Water activity plays a major role in food, which is used to forecast the safety and stability of the product with respect to the growth of microorganisms and chemical reactions. The threshold value of any fried foods which expressed in water activity was less than 0.6 [5]. The variation in water activity of the VF-carrot chips during storage period was graphically displayed in Fig.2. From Analysis of variance, it is understood that the packaging materials and packaging technologies influenced the water activity of VF-carrot chips @1% ($p \leq 0.01$) significant level during the storage period.

From Fig .2, it was observed that after 120 days of storage, the water activity in the VF-carrot chips ranged from 0.511-0.561. The initial water activity of vacuum fried carrot chips packed under various packaging materials/technologies *viz.,* P11, P12, P13, P14, P15 and P16 were 0.314, 0.314, 0.312, 0.316, 0.310 and 0.317, respectively. The final water activity of VF-carrot chips after 120 days of storage *viz.,* P11, P12, P13, P14, P15 and P16 were 0.534, 0.511, 0.527, 0.561, 0.545 and 0.552, respectively.

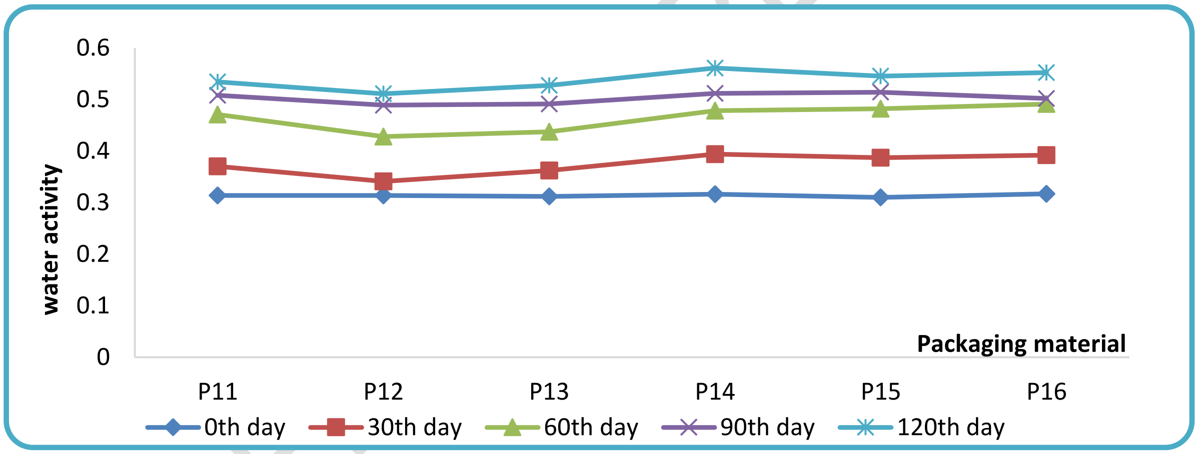

Fig.2. Effect of different packaging materials on water activity ($p \leq 0.01$) during storage of VF-carrot chips

The maximum water activity was observed in LDPE without nitrogen gas (P14) and minimum water activity was found in laminated aluminium pouches with nitrogen gas flushing (P12). The water activity was significantly increased in both treatments and this might be due to the diffusion of moisture in to the packets from surrounding atmosphere during the storage period. An increase in water activity represented that the water vapour was able to permeate from outside atmosphere [14]. These results were in agreement with Ranasalva [15] who found similar results in the storage studies of vacuum fried banana chips. In both cases, the water activity was less than 0.6 and hence considered as safe products.

3.3 Oil content

The changes in the oil content of VF-carrot chips under various packaging treatments were shown in Fig.3. Analysis of variance showed that the effect of packaging materials on oil content had no significant effect during storage period. The oil content of VF-carrot chips was almost constant during the storage period. From Fig.3, the initial oil content of the VF-carrot chips for the samples packed under various packaging materials *viz.,* P11, P12, P13, P14, P15, P16 were 13.51, 13.52, 13.53, 13.52, 13.51, 13.52 %, respectively. The oil content in the VF-carrot chips was constant during the 120 days storage period. The quality of carrot chips packed under nitrogen flushed package was retained during the entire storage period. The replacement of oxygen with inert nitrogen gas inside the package facilitated the storage of VF-carrot chips [16]. Pooja [17] obtained similar results for vacuum fried bitter gourd chips and there was no change in the oil content during the storage period. Manikantan [14] observed that there was no difference in oil content of stored nendran banana chips that were packed in polypropylene based nanocomposite packaging film.

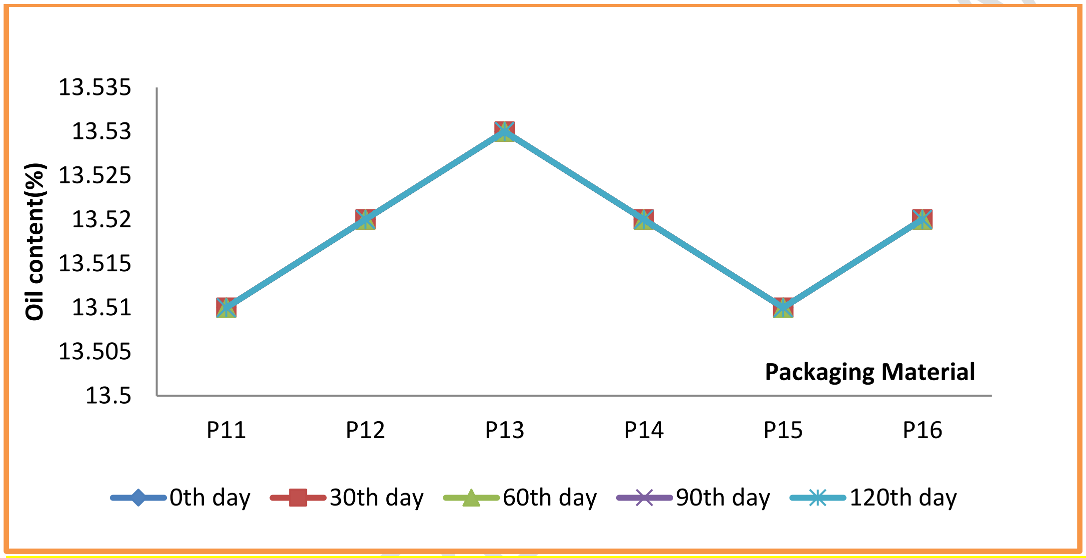

Fig.3. Effect of different packaging materials on oil content ($p\leq0.01$) during storage of VF-carrot chips

3.4 Hardness

The effect of changes in the hardness of VF carrot chips under various packaging materials/techniques during storage is presented in the Fig.4. Analysis of variance showed that the effect of packaging materials and packaging technologies on hardness of stored products was found to be highly significant at 1% level ($p\leq0.01$). From Fig.4, it was observed that the initial hardness values of vacuum fried carrot chips packed under various packaging materials *viz.,* P11, P12, P13, P14, P15 and P16 were 1.52, 1.54, 1.53, 1.51, 1.52, and 1.52 N, respectively. After 120 days of storage the corresponding hardness values of VF-carrot chips were 4.97, 4.41, 4.82, 5.44, 5.08, and 5.18 N, respectively. The highest hardness was observed in P14 (LDPE without nitrogen gas) and lowest hardness was noted in P12 (laminated aluminium pouch with nitrogen gas).

Hardness property was superior in laminated aluminium standard pouch with N_2 gas filling. The increase in moisture content and water activity during the storage period might be influenced the hardness value of the VF-chips [14]. The increase in hardness indicated the reduction in degree of crispness [18]. Ammawath [9] observed the similar results of maximum hardness values found in samples packed under laminated aluminium pouches compared to LDPE pouch during storage of vacuum fried banana chips and deep-fried banana chips.

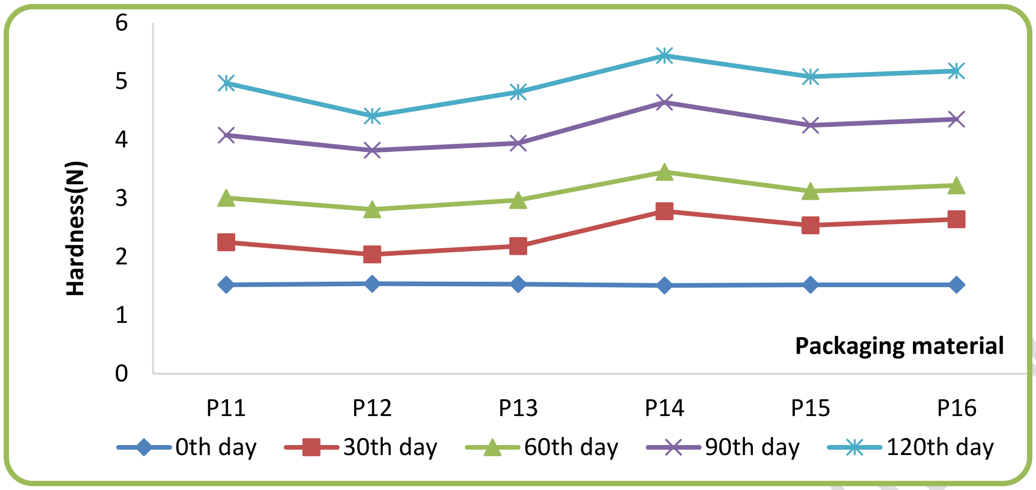

Fig.4. Effect of different packaging materials on hardness ($p \leq 0.01$) during storage of VF- carrot chips

3.5 Color

The color values (L*, a* and b*) values showed significant variation @ 1% ($p \leq 0.01$) during the storage period. The changes in the L* values of VF-carrot chips during the storage period is shown in Fig. 5. L* value of vacuum fried chips increased during the storage period. From Fig.5, it was observed that the initial L* values of vacuum fried carrot chips packed under various packaging materials *viz.,* P11, P12, P13, P14, P15 and P16 were 32.28, 38.28, 38.27, 38.28 38.28, and 38.27, respectively. After 120 days of storage the corresponding L* values of VF-carrot chips were 34.77, 34.4, 34.54, 35.39, 35.51 and 35.28, respectively. The maximum color (L* value) was observed in the samples stored under treatments P14, P15 and P16 which are not filled with nitrogen gas which led to dark colour. The minimum color value was noticed in packets which were filled with nitrogen gas (P11, P12 and P13).The increase in L* value was due to transmission of light through the packaging material [19]. Due to filling of nitrogen gas in the packets, chips retained the good colour. The results were in agreement with Ammawath [9] who had obtained a similar trend of increasing the L* values in the deep-fried banana chips.

The color value a* was inversely proportional with storage period. The change of a* values of the vacuum fried carrot chips during the storage period was displayed in the Fig. 6. From Fig.6 it was noticed that the initial a* values of VF-carrot chips *viz.,* P11, P12, P13, P14, P15 and P16 were 15.21, 15.21, 15.21, 15.22, 15.22 and 15.22 respectively. After 120 days of storage, the corresponding a* values were 13.25, 12.45, 12.01,12.78, 11.45 and 10.87. The maximum reduction of a* value (10.87) was observed in the polypropylene without N_2 gas and there was minimum reduction (P12 and P14) in LDPE packages.

The color value b* was inversely proportional with storage period. The effect of changes in b* values of the vacuum fried carrot chips during the storage period is displayed in the Fig.7. From Fig 7, it was observed that the initial b* values of chips were P11, P12, P13, P14, P15 and P16 were 27.81, 27.82, 27.81, 27.81, 27.82 and 27.81 respectively. After 120 days of storage, the corresponding b* values of VF-carrot chips were 20.05, 19.64, 19.22, 18.85, 18.97 and 18.79 respectively. The maximum reduction of b* values was observed in packets (P14, P15 and P16) which were not filling with nitrogen gas and the minimum reduction of b* values was noted in LDPE with N2 gas flushing (P12). Decrease in yellowness (b* value) was closely associated with degradation of carotenoids during storage which could be due to their isomerisation and oxidation [20]. The decrease in color (a* value) was due to oxidation of brown compounds resulting in slight fading of color. The product slightly got dried up due to evaporation of moisture which also resulted in decrease in color [21]. Similar trend of colour values was observed by Ranasalva [15] for VF-banana chips.

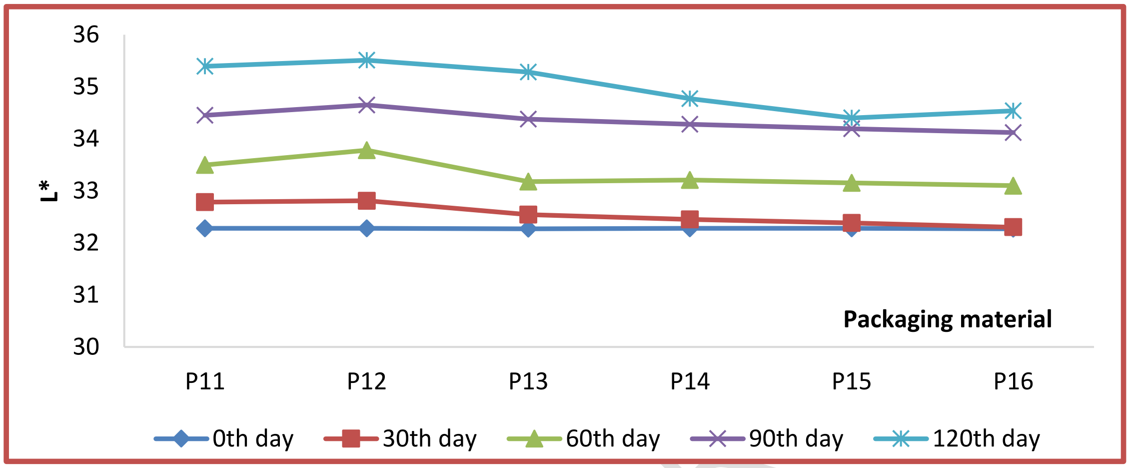

Fig.5. Effect of different packaging materials on L* ($p \leq 0.01$)during storage of VF-carrot chips

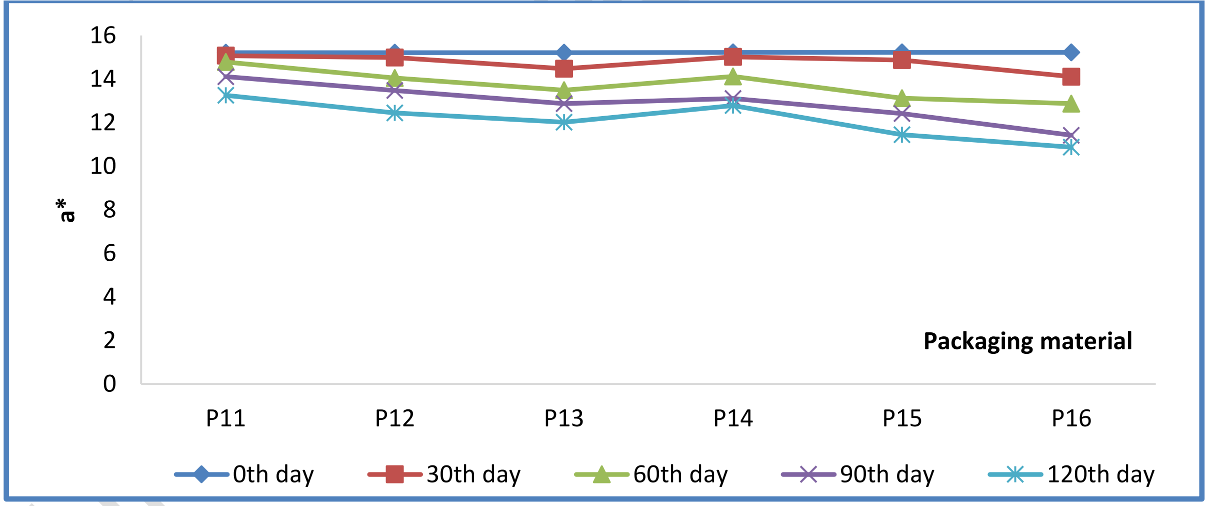

Fig.6. Effect of different packaging materials on a* ($p \leq 0.01$) during storage of VF-carrot chips

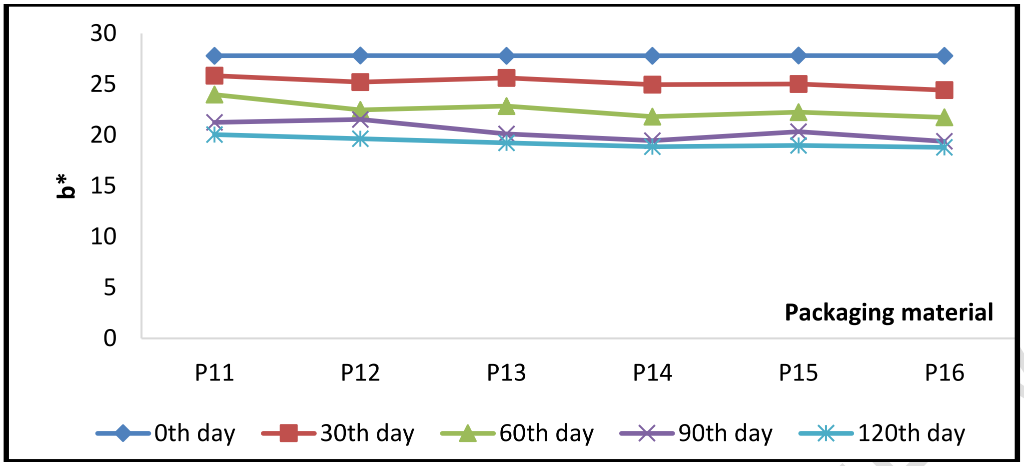

Fig.7. Effect of different packaging materials on b* (p≤0.01) during storage of VF-carrot chips

4. CONCLUSION

Now a days, there is an increasing demand for healthy snacks which provides healthy and nutritious food for consumption to reduce obesity. Carrot chips, with its unique sensory attributes are a popular variety of snacks which is dry and crispy In this regard, carrot chips prepared by vacuum frying could become a popular snack food. Frozen carrots fried in refined palm oil have been found to show good quality. So far, there is a limited availability of ready-to-eat carrots chips in the market. In the processing and storage of vacuum fried carrot chips, proper packaging is important to preserve the quality and storage, which is necessary to enhance the shelf life of the snack foods. Based on the quality parameters and sensory evaluation, the good results were shown in the laminated aluminium flexible pouches with N_2 gas. The moisture content, water activity and hardness values were less in laminated aluminium pouches with N_2 gas flushing compared to polypropylene and LDPE.

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