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Effect of Packaging System and Storage Conditions on Quality Retention of Shelled Walnut

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ABSTRACT

Present study was carried out during 2017 and 2018 at Post-harvest laboratory of ICAR-Central Institute of Temperate Horticulture, Srinagar to assess the effect of packaging condition and storage period on shelled walnut Kernels for enhancing shelf life and retaining quality of shelled walnut. A total of 6 treatments (Traditional air packaging+light, Traditional air packaging+dark, Vacuum packaging+light, Vacuum packaging+dark, Vacuum packaging+Oxygen absorber+light, Vacuum packaging+Oxygen absorber+dark) were applied on shelled walnut kernels. Various observation on sensory attributes, change in fat content, and changes in a physiological loss in weight, firmness, and colour coordinates (kernel L^*, a^*, b^*) was recorded at 0 days and 4 months, 8 months and 12 months. These sensory attributes and overall acceptability score revealed that the overall acceptability of walnut kernels was recorded as highest in T_5 and slightly astringent in T_6. The maximum decrease in fat content was also recorded in T_1 followed by T_2 and the least in T_6 as the storage period advances similarly firmness index decreases as the storage interval increases in a similar pattern. The maximum mean increase in physiological loss in weight was observed in T_1 followed by T_2 and least in T_6 as the storage period advances.The findings of this study revealed that at 12 months of the storage period, vacuum packaging+Oxygen absorber+Dark retained maximum shelf life and maintains the post-harvest quality as compared to traditional air packaging+light. Hence, walnut kernels could be stored in T_6-Vacuum packaging+Oxygenabsorber+dark storage condition for maintaining the quality of walnut kernels for up to 12 months.

KEYWORDS: Walnut, kernel, sensory, colour, packing, storage, ambient temperature

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1. INTRODUCTION

Walnut (*Juglans regia* L.) Belongs to the Juglandaceae family which is one of the finest nuts of temperate regions. It is the oldest cultivated fruit in the world and has grown spontaneously in the union territory of J&K, India.Walnut is much prized as desert and dry fruit and has proven to be nutritionally valuable food (Dogan and Akgul, 2005, Tapsell, 2010).China is the largest walnut-producing country in the world, accounting for 48% of the world's total production of walnut (Fu et al., 2016). Other major producers countries of walnut are the USA, Iran and Turkey (Gharibzahedi et al., 2014, Fu et al., 2016). Walnut is rich in tocopherols and essential fatty acids such as omega-3 and omega-6 (Amin et al., 2017). Day by day, walnuts are gettinggrowing interest as a healthy foodstuff because their regular consumption has been reported to decrease the risk of coronary heart disease(Shah et al., 2017, Uysal et al., 15). Walnut fruits are rich in phenolic compounds (Slatnar et al., 2015) and leaves are good sources of flavonoids (Abuajah et al., 2015).Walnuts are renowned as compared to other nuts due to their higher concentration of polyunsaturated fat content prominently αlinolenic acid ALA levels together with antioxidants like tocopherol (Amarowicz et al., 2017). Its edible part (kernel) represents about 45σ55% of its weight and is consumed either fresh or in roasted form. Kernel skin is a rich source of phenolic compounds and these are known to play a significant role in preventing the oxidation of fatty acids, thus resulting in the longer shelf life of the walnut kernel (Salcedo et al., 2010, Halvorsen et al., 2006,Kornsteiner et al., 2006).Major external factors that affect postharvest nut quality during storage are moisture, temperature and oxygen. During storage increasing temperature and oxygen availability leads to the oxidation of phenolics thus resulting in nutritional and sensory attribute deterioration (Manzocco et al., 2000, Mexis et al., 2009, Golzari et al., 2013, Fu et al., 2018). The quality of packing and storage duration significantly affect the quality of shelled walnut. During various postharvest processes such as drying, storage and packaging, water adsorption and desorption processes play an important role in deteriorative factors such as external and internal browning, lipid oxidation and microbial growth of nut and shell (Tavakolipour, 2015,Tavakolipour and Kalbasi-Ashtari, 2008).Proper packaging of walnut kernels to retain the quality for a longer period under ambient conditions is a major challenge. Lipid oxidation can be inhibited by using a packaging material with low oxygen permeability or by storing the walnuts in atmospheres containing low oxygen content. Storage temperature and condition (light and dark) is another important factor affecting lipid oxidation (Ghanei Zare et al., 2012). Storage of walnut kernels in light and at room temperature has a detrimental effect on the sensory quality and the shelf life of walnut kernels. In J&K, walnut kernels are commonly packed in plastic bags without knowing their properties and suitability. Further, storage of shelled walnut under light is a common practice in Kashmir which may aggravate the deterioration of their nutritional and sensory quality. The high content of polyunsaturated fatty acids in walnut makes them more prone to oxidation which is further speed up by the presence of oxygen. Lipid oxidation is the most important quality parameter decreasing the economic value of walnuts during storage. Oxidation resulting in an undesirable rancid taste makes walnuts unacceptable for the consumer (Bakkalbas et al., 2012). Under such circumstances, the present study is undertaken to find out Better packing system which could retain the quality of shelled walnut over a longer period.

2. MATERIAL AND METHODS

The current study was conducted in 2017 and 2018 at Post harvest laboratory of ICAR-Central Institute of Temperate Horticulture, Srinagar. The site is situated at latitude of 34^0 05' N and longitude of $74^0$50' E at an altitude of 1640 m above the mean sea level. Recommended package of practices followed for better and healthy crop. The average maximum temperature 19.60°C, minimum 6.55°C, rainfall 165.72 cm and relative humidity 60.35 %, evaporation 2.65/day, and soil characteristics, viz. pH= 6.81, EC = 0.36 dS/m were recorded during growing seasons.The walnut variety (CITH-W-3) was harvested in September from the walnut germplasm block of ICAR-Central Institute of Temperate Horticulture, Srinagar. The nuts were harvested at the same maturity stage when the husk was just beginning to split. Immediately nuts were hulled and dried in a cabinet drier at 36°C for 24 h. dried nuts were cracked manually and only healthy kernels free of diseases were selected for the study. Approximately 500 g Kernels packed in 300 gauge thickness polythene consisting of three replication of each of Six different treatments viz., (T_1-Traditional air packaging+light, T_2-Traditional air packaging+dark, T_3-Vacuum packaging+light,T_4-Vacuum packaging+dark, T_5-Vacuum packaging+Oxygenabsorber+light, T_6-Vacuum packaging+Oxygenabsorber+dark were imposed on shelled walnut kernels of genotype CITH Walnut-3. All the treatment was stored at ambient temperature. The sensory evaluation of samples was carried out by 10 semi-trained panellists to score each treatment. A five-point hedonic scale ranging from 1–5, where 1=extremely dislike and 5=extremely like was used to evaluate different parameters such as odour, colour, taste and overall acceptance.Various observations on sensory attributes (astringency, taste, mildew, worm), change in fat content, physiological loss in weight (PLW), firmness and colour coordinates using calibrated Hunter Lab UltraScan PRO colourimeter attached with Easy Match QC software and expressed as L* (lightness;

0=black, 100=white), a* (-a=greenness,+a=redness), and b* (-b=blueness,+b=yellowness) values. Based on L*, a*, and b* was recorded at 0 days, 4 months, 8 months and 12 months of storage. The experiment was carried out in complete randomized design (CRD) and were subjected to analysis of variance (ANOVA) as per Gomez and Gomez (1994) Statistical analysis was carried out using OP STAT software (Sheoranet al., 1998).

3. RESULTS AND DISCUSSION

Analysis of data revealed that packaging materials and storage duration significantly affected the sensory attributes of walnut kernels. The findings of sensory evaluation of walnut kernels stored in different packaging and conditions are given in Table 1.

The sensory evaluation of walnut kernels revealed that a rancid odour of kernels was observed in the treatment, Air packaging+stored in light(T_1), Air packaging+stored in dark (T_2) and Vacuum packaging+storage in light (T_3), however, no rancid odour was observed in Vacuum packaging+storage in dark (T_4), Vacuum packaging+Oxyg enabsorber+storage in light (T_5) and Vacuum packaging+ Oxygen absorber+storage in dark (T_6) even after 12 months of storage period. Although kernels were found to be good

Table 1: Effect of different packaging conditions and storage duration on sensory quality of shelled walnut

Packaging system	Duration	Odour	Pellicle colour	Taste	Mildew & worm	Overall acceptability
T_1: Air packaging+ stored in light	0 month	No rancid	Yellowish white	No astringent	No mildew & worms	Disliked (2)
	4 months	No rancid	Yellowish white	Slight astringent	No mildew & worms	
	8 months	No rancid	Yellowish white	Moderately astringent	No mildew & worms	
	12 months	Rancid	Yellowish dark	Highly astringent	Mildew & no worms	
T_2: Air packaging+ stored in dark	0 months	No rancid	Yellowish white	No astringent	No mildew & worms	Disliked (2.5)
	4 months	No rancid	Yellowish white	Slight astringent	No mildew & worms	
	8 months	No rancid	Yellowish white	Moderately Astringent	No mildew & worms	
	12 months	Rancid	Yellowish	Highly astringent	Mildew & no worms	
T_3: Vacuum packaging+ storage in light	0 month	No rancid	Yellowish white	No astringent	No mildew & worms	Slightly liked (3.0)
	4 months	No rancid	Yellowish white	Slightly astringent	No mildew & worms	
	8 months	No rancid	Yellowish white	Moderately astringent	No mildew & worms	
	12 months	Rancid	Yellowish	Moderately astringent	No mildew & worms	
T_4: Vacuum packaging+ storage in dark	0 month	No rancid	Yellowish white	No astringent	No mildew & worms	Slightly liked (3.0)
	4 months	No rancid	Yellowish white	Slightly astringent	No mildew & worms	
	8 months	No rancid	Yellowish white	Slightly astringent	No mildew & worms	
	12 months	No rancid	Yellowish	Moderately astringent	No mildew & worms	
T_5: Vacuum packaging+ Oxygenabsorber+ storage in light	0 month	No rancid	Yellowish white	No astringent	No mildew & worms	Moderately liked (4.0)
	4 months	No rancid	Yellowish white	No astringent	No mildew & worms	
	8 months	No rancid	Yellowish white	Slightly astringent	No mildew & worms	
	12 months	No Rancid	Yellowish white	Moderately astringent	No mildew & worms	
T_6: Vacuum packaging+ Oxygen absorber+ storage in dark	0 month	No rancid	Yellowish white	No astringent	No mildew & worms	Extremely liked (5.0)
	4 months	No rancid	Yellowish white	No stringent	No mildew & worms	
	8 months	No rancid	Yellowish white	No stringent	No mildew & worms	
	12 months	No rancid	Yellowish white	Slightly astringent	No mildew & worms	

and edible in 4th and 8th months of storage, there were sharp increases in the hedonic score after six months and all walnuts kernels were found to be very rancid and inedible in Air packaging+stored in light (T_1), Air packaging+stored in dark (T_2) and Vacuum packaging+storage in light (T_3) as compared to Vacuum packaging+storage in dark (T_4), Vacuum packaging+Oxygenabsorber+storage in light (T_5) and Vacuum packaging+ Oxygen absorber+storage in dark (T_6).Similarly, pellicle colour and taste were observed as yellowish white in Vacuum packaging+Oxygenabsorber +storage in light (T_5) and Vacuum packaging+ Oxygen absorber+storage in dark (T_6) as compared to yellowish dark in Air packaging+stored in light (T_1) and yellowish in Air packaging+stored in dark (T_2) and Vacuum packaging+storage in light (T_3).Change in kernel colour is attributed to the hydrolysis of phenolic substance present in the outer covering of walnut kernels as a result of exposure to light and oxygen (Bhatia et al., 1984). Besides, other constituents like polysaccharides and reducing and non-reducing sugars also contribute to colour deterioration. The taste of kernel was observed highly astringent in Air packaging+stored in light (T_1), Air packaging+stored in dark (T_2), moderately astringent in Vacuum packaging+storage in light (T_3), Vacuum packaging+storage in dark (T_4) and Vacuum packaging+Oxygenabsorber+storage in light (T_5) and slightly astringent in Vacuum packaging+ Oxygen absorber+storage in dark (T_6) after 12 months of storage. There was no development of mildew and worm in kernels was Vacuum packaging+storage in light (T_3), Vacuum packaging+storage in dark (T_4), Vacuum packaging+Oxygenabsorber+storage in light (T_5) and Vacuum packaging+ Oxygen absorber+storage in dark (T_6) as compared to Air packaging+stored in light (T_1) and Air packaging+stored in dark (T_2) treatment after 12 months of storage. Taste deterioration in packed food materials depends on the availability of oxygen and moisture. Vacuum packaging+ Oxygen absorber+storage in dark are devoid of oxygen and moisture which discourage oxidative rancidity. Further, there is some build-up of CO_2 in the packaging. CO_2 is a known oxygen-antagonistic agent which prevents oxidative rancidity in fatty foods. CO_2 also lowers the pH of stored foods, thus discouraging any microbial growth (Prabhakar, 1977, Xie et al., 2018).Lipid oxidation occurs during the storage of peanuts and leads to the development of undesirable flavours and colours (Liu et al., 2019). The oxidation reactions first lead to the formation of hydroperoxide, which further forms into secondary oxidation products, such as ketones and aldehydes. Based on these sensory attributes, the overall acceptability of walnut kernels was recorded as highest in Vacuum packaging+Oxygenabsorber+storage in light and slightly astringent in Vacuum packaging+ Oxygen absorber+storage in dark.

The packageing and storage condition also affected kernel appearance and visual quality in terms of colour (L^*, a^* and b^*) traits are given in Table 2.

Among packaging systems,thehighest change in the value of L^* was recorded in Air packaging+stored in light (T1) by Air packaging+dark (T_2) however,the minimum was in Vacuum packaging+Oxygenabsorber+dark (T_6). As the duration of storage advance L^* value decrease irrespective

Table 2: Effect of packaging condition and storage duration on kernel colour (L*, a* and b*) traits

Packaging system	L*				Mean	a*				Mean	b*				Mean
	Storage duration (month)					Storage duration (month)					Storage duration (month)				
	0	4	8	12		0	4	8	12		0	4	8	12	
T_1	39.98	37.64	30.12	25.31	33.26	2.61	2.56	2.1	1.89	2.29	33.56	33.5	33.12	30.12	32.58
T_2	36.78	34.38	30.45	27.36	32.24	3.88	3.73	3.62	3.5	3.68	41.78	39.68	38.45	36.45	39.09
T_3	28.89	27.14	24.68	22.56	25.82	2.12	2.02	1.98	1.87	2.00	31.56	30.33	29.54	28.12	29.89
T_4	29.78	28.2	27.98	25.68	27.91	0.74	0.55	0.5	0.47	0.57	38.56	37.9	36.14	35.17	36.94
T_5	33.2	32	30.47	28.69	31.09	1.52	1.5	1.37	1.34	1.43	40.65	39.05	38.34	36.24	38.57
T_6	31.5	31.00	30.25	29.32	30.52	1.65	1.6	1.57	1.56	1.60	36.44	35.27	34.15	33.68	34.89
Mean	33.36	31.73	28.99	26.49		2.09	1.99	1.86	1.77		37.09	35.96	34.96	33.30	
	F_1: (CD p=0.01)- 1.51 F_2: (CD p=0.01)- 4.23 $F_1 \times F_2$:(CD p=0.01) -2.15					F_1: (CD p=0.01)- 0.35 F_2: (CD p=0.01)- 0.23 $F_1 \times F_2$: (CD p=0.01) -0.15					F_1: (CD p=0.01)- 1.11 F_2: (CD p=0.01)- 1.23 $F_1 \times F_2$: (CD p=0.01) -1.05				

T_1: Air packaging+light; T_2: Air packaging+dark; T_3: Vacuum packaging+light; T_4: Vacuum packaging+dark; T_5: Vacuum packaging+Oxygenabsorber+light; T_6: Vacuum packaging+Oxygenabsorber+dark; F_1: Factor 1 (Packaging system); F_2: Factor 2 (Storage duration); $F_1 \times F_2$: Factor 1 (Packaging condition)* Factor 2 (Storage duration) of the packaging system. The gradual decrease in L* values of the shelled walnut might be due to an increase in the formation of brown pigment melanoidins formed due to the non-enzymatic browning of whole walnuts at high temperatures and high water activity. Ahad et al. (2017), Ahad et al. (2020) and Christopolusand Tsantili (2011) reported that higher concentrations of reducing sugars which cause the colour to change to brown and observed a decrease in colour values of the walnut kernel during storage. The results conform with the findings of Ziaolhagh et al. (2017) who reported that the lightness of walnut kernels decreased during storage of three months.

Data on the effect of packaging materials and storage periods on the a* value of shelled walnuts revealed that packaging materials and storage periods significantly affected a* value of shelled walnuts. Contrast results were observed by Ahad et al. (2017)who reported an increase in a* value in whole black walnuts and Kahyoglu (2008) who reported the same trend during an investigation on the storage of pistachio nuts (Yaman, 2004). Similarly, Among packaging systems maximum change in the value of a* was recorded in Air packaging+light (T_1) followed by Air packaging+dark (T_2), however, minimum in Vacuum packaging+Oxygenabsorber+dark (T_6) and as the duration of storage increasesthe a* value decrease irrespective ofthepackaging system.

Similarly, among packaging systems maximum change in the value of b* (which represents yellowness) was also recorded maximum in Air packaging+light (T_1) followed by Air packaging+dark (T_2), however, minimum in Vacuum packaging+Oxygenabsorber+dark (T_6). With the advancement of the storage period, there was a gradual decrease in b* values of the shelled walnut kernels.The interaction effects between the packaging materials and storage periods were also found to be significant. With the advancement of the storage period, there was a gradual decrease in all colour parametersL*, a*, b* values of the walnut kernels mainly ascribed to enzymatic or chemical oxidation of phenolics (Monzoco et al., 2001). Kahyoglu (2008) also observed a decreasing trend in b* value in Pistachio nuts.

The maximum decrease in fat content was also recorded in Air packaging+light (T_1) followed by Air packaging+dark (T_2), and least in Vacuum packaging+Oxygenabsorber+dark (T_6) as the storage period advances (Figure 1, Figure 2, Figure 3)

Oxygen concentration is one of the most important environmental factors affecting lipid oxidation. Lipid oxidation can be inhibited by using a packaging material with low oxygen permeability or by storing the walnuts

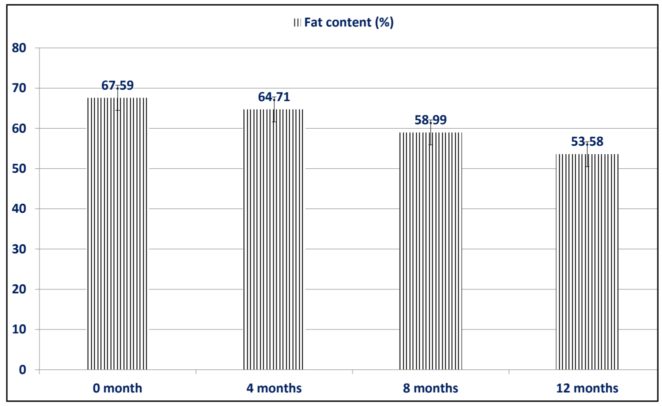

Figure 1: Effect of storage duration on kernel fat content

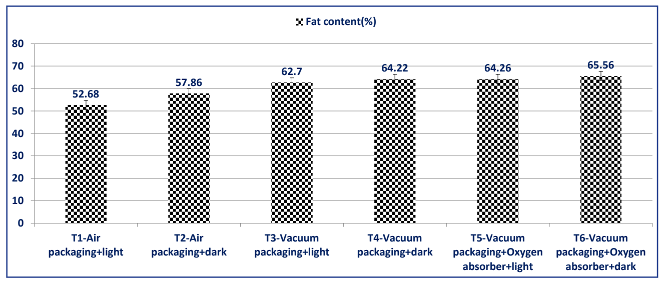

Figure 2: Effect of packaging system on kernel fat content

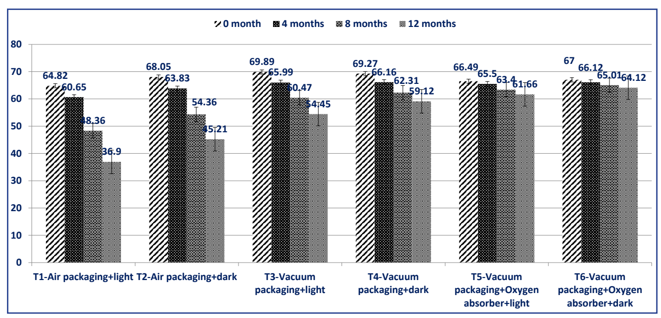

Figure 3: Interaction effect of packaging system and storage onkernel fat content

in atmospheres containing low oxygen content (Rastegar et al., 2019, Salajeghehand Tajeddin, 2020). Jensen et al. (2001) and Mexis et al. (2009) found significant oxidative changes in walnuts stored in lights at 21°C.Findings reveal that packaging materials and storageperiods significantly affectedthefirmness index of walnutkernels (table 3). The mean firmness Index decreases as the storage interval increase, however,themean increase in physiological loss in weight was observed in T_1 followed by T_2 and at least in T_6 as the storage period advances.As the storage period advances increase in physiological loss in weight was observed due to the increased oxidation process.Shelf life enhancement of walnut by vacuum packaging in the different polymers has been already reported by several workers andTajeddin (2004) and Tao et al. (2008) have also revealed relation between types of packaging and lipid oxidation in walnuts

Table 3: Effect of the packaging system and duration on kernel fat content, firmness and physiological loss in weight

Firmness Index					Physiological loss in weight (PLW)				
0 month	4 months	8 months	12 months	Mean	0 month	4 months	8 months	12 months	Mean
79.54	78.66	70.45	60.32	72.24	80.00	78.34	69.32	60.36	72.01
74.18	73.5	68.35	62.34	69.59	80.00	78.98	70.65	60.1	72.43
68.92	68.36	64.45	60.35	65.52	80.00	79.10	72.65	65.13	74.22
72.82	72.3	69.12	64.65	69.72	80.00	79.25	75.47	71.45	76.54
72.82	72.3	69.12	64.65	69.72	80.00	79.45	76.78	73.65	77.47
67.32	66.96	65.78	63.88	65.99	80.00	79.65	77.82	75.87	78.34
72.60	72.01	67.88	62.70		80.00	79.13	73.78	67.76	75.17
F_1 (CD p=0.01)- 3.61 F_2: (CD p=0.01)- 4.13 F_1×F_2 (CD p=0.01) -3.25					F_1: (CD p=0.01)- 3.23 F_2: (CD p=0.01)- 3.53 F_1×F_2 (CD p=0.01) -3.65				

F_1: Factor 1 (Packaging system); F_2: Factor 2 (Storage duration); F_1×F_2: Factor 1 (Packaging condition)* Factor 2 (Storage duration)

4. CONCLUSION

From the study is opined that walnut kernels could be stored up to 12 months in vacuum packaging+oxygen absorber+dark storage conditions for maintaining sensory and bio-chemical quality of walnut kernels.

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