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Studies on drying, packaging and storage of solar tunnel dried chilgoza nuts

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ABSTRACT

Chilgoza (Pinus gerardiana) is one of the pine nuts among six species found in India which produce edible nuts. Because of the traditional handling of this nut by tribals, it lasts only for few weeks in the market. Studies were undertaken to compare the solar drying modes for drying of this nut and screen out the suitable packaging material for its storage. Extracted nuts were dried under three solar drying means like solar cabinet drier (46-52 °C), solar tunnel drier (43-47 °C) and open sun (18-22°C). Solar tunnel drier was found to be best drying mode for drying quality nuts as compare to the others. So, nuts dried in this drier were packed in five different packaging materials and stored under ambient conditions for six months. The some physico-chemical quality characteristics like a_w (0.208), oil (49.1%) total carbohydrates (24.9%), and proteins (11.8%) and sensory quality attributes of packed nuts were retained better in glass jars closely followed by aluminum laminate pouch after six months of storage as compared to others. Solar tunnel drier was the best drying mode and glass jar as well as aluminum laminate pouch were the best materials for packaging and storage.

Key words: Chilgoza, Solar tunnel drier, Solar cabinet drier, Aluminum laminate pouch

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INTRODUCTION

There is about 20.64 % area under forest in India where various species of trees are found depending upon climatic conditions. There are about 29 species of pine which produce edible nuts those are utilized by indigenous tribal cultures in the world. However, in India, out of six species of pine, *Pinus gerardiana* is the only species which produces edible and highly nutritious nuts [1]. This species is distributed not only in India but also in Afghanistan, Tibet, Baluchistan (Pakistan) [2,3] between 2000 and 3350 m elevation [4,5]. In India it is distributed only in Himachal Pradesh (Kinnaur and Chamba Districts), and Jammu and Kashmir.

Chilgoza is a small to medium sized evergreen pine tree with short and horizontal branches forming a tree of compact habit. As a timber tree, it is of little importance but its seeds or nuts are edible which has got an economic importance. The edible nuts are highly nutritious having carminative, stimulant and expectorant properties. Its kernels are rich source of oil, proteins and carbohydrates with no cholesterol like other edible pine nuts [6].

This is the only pine which is of immense social forestry importance because most of the tribals of Kinnaur district of Himachal Pradesh (HP) depend on the income from nuts of this pine tree. Tribals have got the rights to harvest the seeds/ nuts from this pine tree for their livelihood. This also forms an important part of their diet as well as for various social obligations. Tribals handle this crop traditionally by adopting the age old practice. After harvesting

the cone and extraction of nuts from the cones they sell their produce to the local traders immediately without drying. Some unsold proportion of the nuts is stored in the traditional stores for later selling as well as for social obligations. Nuts in the market as well as in the traditional stores have short shelf life as a result of oxidative rancidity; attack by storage fungi and by nut borer. Hence, drying is the foremost step to extend the shelf life of chilgoza nuts. It is well known that drying prevents postharvest losses of nuts by inhibiting fungal activity, prevents insect damage and improves chemical and physical stability of food [7]. Although efforts have been made to standardize the pre-drying treatment of chilgoza nut [6] but no efforts have been made so far to find out suitable drying mode and packaging material for packing and storage of dried chilgoza nuts. No literature on the packaging and storage of chilgoza nuts is available. The present studies were carried out for the first time to evaluate the drying modes and suitable packaging material for packaging and storage of dried nuts.

MATERIALS AND METHODS

Mature green chilgoza cones were procured from the different villages of the Kinnaur district of HP for conducting the present studies. Packaging and other material were procured from the local market of Solan town of the state.

Extraction and drying of nuts

Nuts were extracted from the cones as explained by [6]. Extracted chilgoza nuts (1 kg) were subjected to drying in sun (18-22°C), solar tunnel drier (43-47°C), and solar cabinet drier(46-52°C) latter both manufactured locally by M/S Surya Structural, Solan, HP. Nuts were dried in these drying modes till their constant weight. Best quality nuts dried under certain drying mode were were selected for storage studies.

Evaluation of packaging material for packing and storage of dried nuts

The best dried chilgoza nuts were packed in five different packaging materials like i) HDPE jar (P_1), ii) glass jar (P_2), iii) polyethylene pouch, 93.9 gsm (P_3), iv) aluminium laminate pouch, 99.8 gsm (P_4), v) thermofoam tray wrapped with strech wrap film (P_5) each of 250 g capacity and stored at ambient (15-25°C) temperature for a period of six months. The changes in various physico-chemical and sensory characteristics during storage were studied at an interval of three months.

Physico-chemical characteristics of nuts*:*

The fresh as well as dried nuts were analyzed for various physico-chemical characteristics as per standard methods of analysis. The random samples of 50 nuts each of fresh and dried were selected to study their various physical characteristics. The water activity (a_w) of the nuts was estimated with water activity meter (HygroLab 3 model) from M/S Rotronic ag Switzerland. The colour of nuts and kernel was compared with the colour charts of Royal Horticultural Society, London. The chemical characteristics such as reducing and total sugars of nuts were estimated as per Nelson-Somogyi's method [8] and phenol sulphuric acid method was used to estimate the total carbohydrates. The proteins were analysed as per the Lowry's method [9]. The moisture, oils, and fibres content were also estimated as per standard methods [10]. Nuts were evaluated for sensory quality by 10 semi-trained panelists on the basis of colour, texture, taste and overall acceptability on a 9 point Hedonic scale (9-like extremly, 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, 1-dislike extremely) [10]. The experiments were replicated as mentioned in the respective tables. Statistical analysis of data of various parameters including physico-chemical characteristics was carried out by CRD [11] and sensory analysis by RBD [12].

RESULTS AND DISCUSSION

Physico-chemical characterstics of fresh and dried chilgoza nuts

Table 1 shows the physico-chemical and sensory characterstics of fresh and dried chilgoza nuts. The visual colour was observed as brown 200D in fresh as well as in dried nuts. The average moisture and a_w of fresh nuts were 29.6$\pm$ 1.5% and 1.0, respectively. In the fresh nuts, oil content was recorded as 6.9$\pm$ 0.45 % and proteins as 2.0$\pm$0.10%. Total carbohydrates, total sugars, and reducing sugars in the fresh nuts were found to be 4.0$\pm$ 0.02, 2.6$\pm$ 0.09, 1.0$\pm$ 0.02 %, respectively. The fibres content in the same nuts were 0.28$\pm$ 0.03 %, whereas, ash content was 0.40$\pm$0.12 %.

The moisture and a_w were observed as 6.8$\pm$ 0.20%, 0.169$\pm$ 0.003, respectively in the dried nuts and quite a high amount (49.4$\pm$1.5%) of oil content was observed in the same nuts. However, other constituents like proteins,

total carbohydrates, total sugars and reducing sugars were observed as 12.0±0.85%, 24.5±1.2%, 17.2± 1.0% and 5.9±0.38 % , respectively in dried nuts. The fibres content in the dried nuts was 1.8±0.02 %, whereas, ash content was 2.7±0.09 %.

Sensory characteristics like colour, texture, taste and overall acceptability were observed as 7.8± 0.18, 5.7±0.10, 5.4±0.14 and 6.3±0.16, respectively in the freshly extracted nuts. Texture and taste scores showed that they were not much liked by the judges in the fresh form. Whereas, dried nuts scored higher for colour, texture, taste and overall acceptability as 7.5±0.12, 7.4± 0.13, 7.6+0.14,7.6±0.10, respectively.

Table 1 - Physico-chemical and sensory characteristics of fresh and dried chilgoza nuts

Characteristics	Fresh Mean±SE	Dried Mean±SE
Physico-chemical		
Colour	Brown 200D	Brown 200D
Moisture,%	29.6±1.5	6.8 ±0.2
Water activity	1.00	0.182±0.003
Oils,%	6.9±0.45	49.4±1.5
Protiens,%	2.0±0.10	12.0±0.86
Total Carbohydrates,%	4.0±0.02	24.5±1.2
Total sugars,%	2.6±0.09	17.2±1.0
Reducing sugars,%	1.0±0.02	5.9±0.38
Fibers,%	0.28±0.03	1.8±0.02
Ash,%	0.40±0.12	2.7±0.09
*__Sensory Characteristics,__ scores		
Colour	7.8±0.18	7.5±0.12
Texture	5.7±0.10	7.4±0.13
Taste	5.4±0.14	7.6±0.14
OA	6.3±0.16	7.6±0.10

** Based on 9 point Hedonic scale (Nr of panelists 10), OA=Overall acceptability, (n=3)*

Table 2- Effect of different drying modes on chilgoza nut drying

Drying Modes	Drying Time h	Temperature of drying modes, °C	Water activity	Moisture %	Defects	Sensory quality			
						Color	Texture	Taste	OA
Solar Cabinet Drier	128	46-52	0.208	7.4	Oil oozed out	8.0	6.2	4.0	6.0
Solar Tunnel drier	160	43-47	0.182	6.8	-	8.0	8.1	8.0	8.1
Sun	192	18-22	0.235	8.5	-	7.9	6.8	6.9	7.1
CD at 5%	-	-	0.150	0.8	-	0.7	1.3	1.0	0.7

*OA= Overall acceptability, *Based on 9 point Hedonic scale (Nr of panelist 10), (n=4)*
SE=Standard error of mean

Screening of drying modes for drying of nuts

Among the various modes (Table 2) the time taken to dry the nuts (till their constant weight) ranged from 128 to 192 h. It took minimum time (128 h) to dry the nuts in solar cabinet drier and maximum (192 h) in sun. The moisture content of nuts ranged between 6.8 and 8.2% with lowest in solar tunnel drier. Similar trend was observed in the a_w of the nuts dried in various modes. The data in Table 2 show significant differences among the various modes of

drying of nuts for sensory quality scores of colour, texture, taste and overall acceptability of nuts. The higher colour, texture, taste and overall acceptability scores of nuts dried in tunnel drier showed its superiority over other drying modes. These observations indicate that drying of nuts at 43-47°C for 160 h in solar tunnel drier had an advantage over the other modes that is of its low cost. Further, all other methods had low sensory scores and hence rejected.

Packaging and storage of dried nuts

1. Chemical characteristics*:*

Moisture, a_w and oil

During storage of 6 months, a significant increase in moisture content of nuts (Table 3) from the intial values of 6.8 to 7.4 % was observed irrespective of any packaging material. The minimum moisture content (6.9%) of nuts was observed in the glass jar and aluminium laminate pouch and maximum in thermofoam tray (7.4%) during storage.

A general increase in the moisture content of dried nuts observed during storage is in agreement with the earlier findings [13]. Increase in the moisture content could be due to the decomposition of oil content in the nuts. However, changes in moisture content vary with the packaging materials during storage. This might be due to the differences in the level of moisture permeability possessed by the packaging material [14] and glass, aluminum laminate pouch offered a better protective barrier against moisture than thermo foam tray and polyethylene pouch [15]. Increase in moisture content of cashew nut packed in different packaging materials has also been reported. Glass and plastic bottle offers a better barrier against moisture than polyethylene pouch during packaging and storage of dried cashew nuts in ambient storage conditions [16]. The difference between packaging materials may be due to their thermal conductance properties which affect the internal decomposition reactions in the products during storage.

Table 3 - Effect of different packaging materials on the moisture, a_w and oil content of dried chilgoza nuts during storage

Treatment	Package	Days in storage			
		3	6	Mean	CD $_{at\ 5\%}$
Moisture, %	P_1	7.0	7.3	7.0	P= 0.3 S= 0.2 PxS= 0.5
	P_2	6.9	6.9	6.9	
	P_3	7.1	7.6	7.2	
	P_4	6.9	7.0	6.9	
	P_5	7.5	7.9	7.4	
	Mean	7.1	7.4		
a_w	P_1	0.235	0.285	0.234	P= 0.040 S= 0.036 PxS=0.060
	P_2	0.201	0.242	0.208	
	P_3	0.260	0.305	0.249	
	P_4	0.210	0.245	0.212	
	P_5	0.285	0.331	0.266	
	Mean	0.238	0.282		
Oil, %	P_1	49.2	48.5	49.0	P= 0.1 S= 0.1 PxS= 0.2
	P_2	49.3	48.6	49.1	
	P_3	49.1	48.2	48.9	
	P_4	49.3	48.5	49.1	
	P_5	49.1	47.7	48.7	
	Mean	49.2	48.3		

$P_{1=}$ HDPE jar, $P_{2=}$ glass jar, $P_{3=}$ polyethylene pouch, $P_{4=}$ aluminium laminate pouch
$P_{5=}$ thermofoam tray, (n=3), a_w = water activity, (n=3)
Initial values at the time of commencement of storage: Moisture=6.8%, a_w=0.182, Oils =49.4%

Significant increase in a_w of the nuts during storage in the ambient conditions indicates that it increased from an intial values of 0.182 to 0.282. It was however observed to be lowest (0.208) in the nuts packed and stored in glass jar closely followed by aluminium laminate pouch and HDPE jar and maximum in the thermofoam tray (0.266) during storage.

A significant increase in the a_w found in the nuts during storage might be due to the absorption of moisture by the nuts in the different packaging material. Although there was increase in a_w in the nuts in different packages during

storage but it was within the limit for safe storage of edible nuts at a_w below 0.53 at 25 $^{\circ}$C for 6 months [17]. Dried foods are usually packaged and stored to keep a_w value near to 0.3, where microbial, chemical, biochemical and physical changes are minima [18]. However, a_w values between 0.3-0.4 in dried food containing high oil becomes susceptible to lipid oxidation. The minimum increase in a_w of nuts packed in glass jar in the present studies might be due to its better moisture barrier as compared to other packages during storage.

With the passage of time in the storage measurable oil content of dried nuts (Table 4) decreased significantly from the intial values of 49.4 to 48.3% . However, the maximum content of measurable oils (49.1%) of the nuts retained in glass jar and aluminium laminate pouch and HDPE jar and minimum in thermofoam tray (48.7%).

Table 4 - Effect of different packaging materials on the total carbohydrates, reducing and total sugars, proteins and fibers of dried chilgoza nuts during storage

Treatment	Package	Days in storage			
		3	6	Mean	CD $_{at\ 5\%}$
Total Carbohydrates, %	P_1	24.5	25.4	24.8	
	P_2	24.6	25.6	24.9	P= NS
	P_3	24.5	25.6	24.9	S= NS
	P_4	24.5	25.3	24.8	PxS= 0.5
	P_5	24.5	25.2	24.7	
	Mean	24.5	24.6		
Reducing sugars, %	P_1	6.0	7.1	6.4	
	P_2	6.2	7.8	6.6	P= NS
	P_3	6.1	7.1	6.4	S= NS
	P_4	6.1	7.6	6.6	PxS= 0.3
	P_5	6.0	7.1	6.4	
	Mean	6.1	7.3		
Total sugars, %	P_1				
	P_2	17.5	18.5	17.7	P= NS
	P_3	17.6	19.2	18.0	S= NS
	P_4	17.4	17.6	17.4	PxS= 0.4
	P_5	17.6	17.8	17.6	
	Mean	17.5	18.2		
Proteins, %	P_1	11.2	11.1	11.4	
	P_2	11.8	11.6	11.8	P= 0.3
	P_3	11.3	10.6	11.3	S= 0.1
	P_4	11.8	11.5	11.8	PxS= 0.6
	P_5	11.2	10.9	11.4	
	Mean	11.5	11.1		
Fibres, %	P_1	1.7	1.6	1.7	
	P_2	1.8	1.7	1.8	P= 0.1
	P_3	1.7	1.6	1.7	S= NS
	P_4	1.7	1.7	1.7	PxS= 0.3
	P_5	1.6	1.5	1.6	
	Mean	1.7	1.6		

$P_{1=}$ HDPE jar, $P_{2=}$ glass jar, $P_{3=}$ polyethylene pouch, $P_{4=}$ aluminium laminate pouch $P_{5=}$ thermofoam tray, (n=3), Initial values at the commencement of storage: Total carbohydrates=24.5%, reducing sugars=5.9%, total sugars=17.2%, proteins=12.0%, fibres=1.8%

Carbohydrates, reducing sugars, total sugars, proteins and fibres

Table 4 reveals that there were non significant changes with respect to total carbohydrates, reducing and total sugars content of the nuts during storage of six months. Also no significant differences were observed among the different packages during storage of 6 months in the ambient conditions.

During storage of six months a significant decrease in measurable protein content of nuts from intial values of 12.0 to 11.1 % was observed. However, the maximum content of this attribute was retained in the glass jar and

aluminium laminate pouch and minimum in polyethylene pouch (11.3%). No significant decrease in fibre content in the nuts was observed during storage but it decreased significantlywhile comparing the packaging material during storage. The maximum (1.8%) content of fibres in the nuts were retained in glass jar followed by aluminium laminate pouch and minimum in thermofoam tray (1.6%).

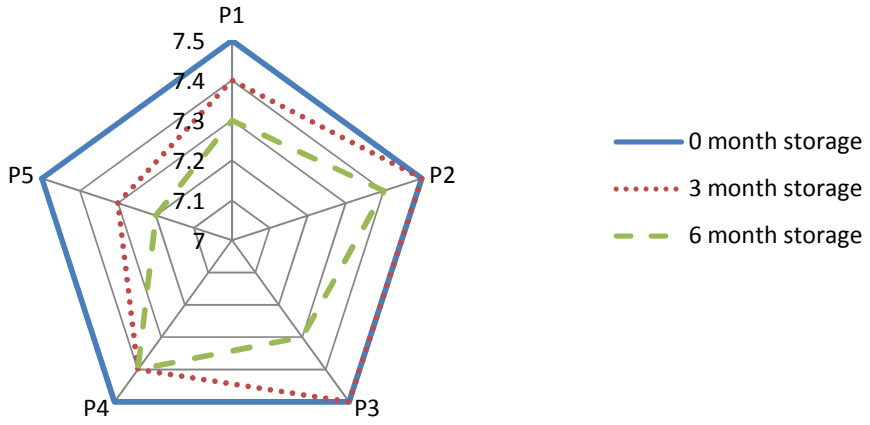

Fig. 1 Effect of different packaging material on the sensory scores for color of dried chilgoza nuts.

Decrease in the measurable protein content in the nuts observed during storage might be due to the participation of nitrogenous compounds in some chemical reactions during storage. However, minimum losses of measurable protein in the nuts packed in the glass jars and aluminium laminate pouch might be due to the participation of lower amount of nitrogenous compounds in chemical reactions because of the better packaging conditions. Decrease in the protein content of the chilgoza seeds in the various storage temperature conditions have also been reported [19]. The negligible loss of fibres in glass jar and aluminium laminate pouch might have restricted the conversion of fibres into sugars in the chemical reactions because of better packaging conditions during storage.

2. Sensory characteristics:

The changes in sensory attributes of the nuts during storage have been presented in the form of web diagrams in Fig 1-4. No significant changes with respect to colour score were observed in the nuts in all the packages during storage of six months. However, significant decrease in the scores of texture, flavour and overall acceptability of the stored nuts were observerd during storage. Texture scores significantly decreased from the intial values of 7.6 to 7.2. Flavour scores decreased significantly from the intial values of 7.8 to 7.2 and overall acceptability scores also decreased significantly from the initial values of 7.8 to 7.2. However, the highest scores of texture , flavour and overall acceptability of the nuts packed in the glass jar closely followed by aluminium laminate pouch were observed during storage.

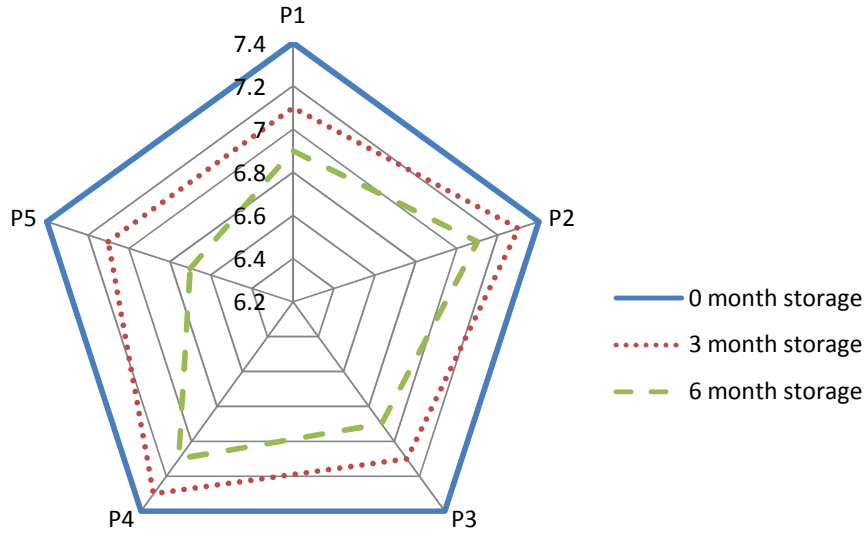

Fig. 2 Effect of different packaging material on the sensory scores for texture of dried chilgoza nuts.

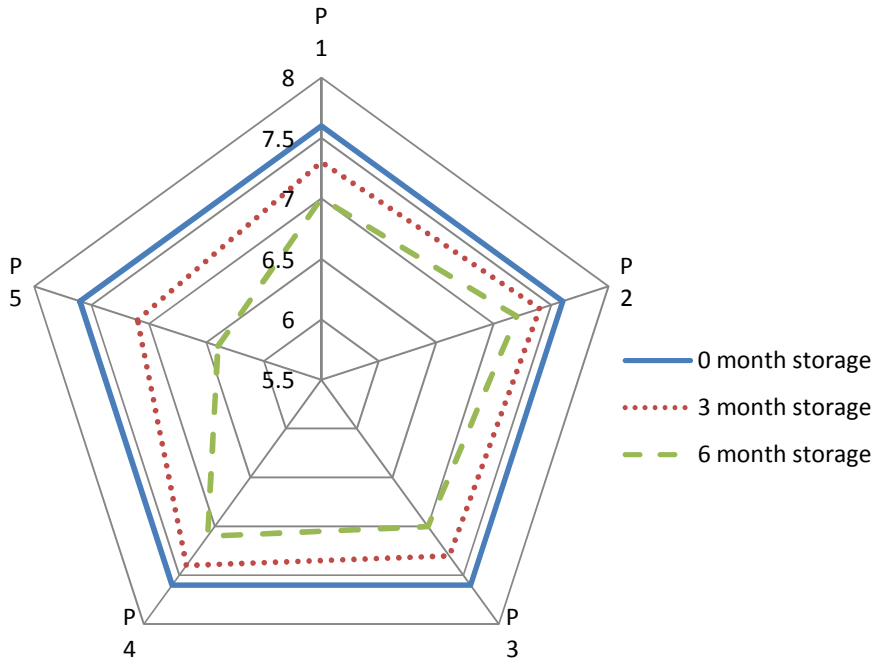

Fig.3 Effect of different packaging material on the sensory scores for taste of dried chilgoza nuts.

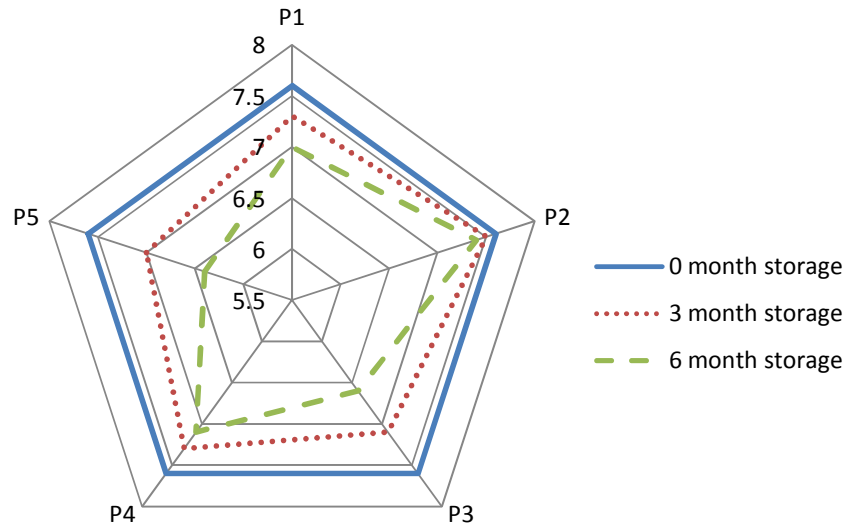

Fig. 4 Effect of different packaging material on the sensory scores for overall acceptability of dried chilgoza nuts during storage

The highest scores retained in the nuts packed in the glass jar followed by aluminium laminate pouch might be due to the better texture retained during the storage in these packaging materials and not much loss in taste and aroma might be due to the lesser loss of fatty acids due to the oxidation in these containers. Better overall acceptability scores of nuts reflects the better quality retention by these packages in the nuts during storage. Decrease in texture (crispness), taste, aroma scores in the walnut during storage have been reported which might be due to the moisture absorption by nuts and oxidation of fats which affected their texture, taste and aroma. LDPE film with aluminium foil act as best package compared to others for packing of walnut during storage [20,21,22]. Sensory quality of packed almond to be preserved better for eight months under ambient temperature conditions in films having better oxygen barrier properties [23] . If the entry of light and oxygen to the package is prevented , it reduces the preservation requirements and increase the shelf life of the dried hazel nuts [24,25,26].

CONCLUSION

Solar tunnel drier was the best mode of drying of nuts on the basis of some physico-chemical and sensory characteristics of dried chilgoza nuts, whereas, glass jar and aluminium laminate pouch were the best packaging materials for the storage of nuts on the basis of their better retention of physico-chemical and sensory attributes. Aluminium laminate pouch is light weight and easy to handle as compared to glass jar, hence it can be recommended for the packaging of dried chilgoza nuts on conmmercial scale.

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REFERENCES

[1] B.L. Gupta, Forest flora of Chakrata, Dehradun and Saharanpur, Forest Research Institute, Dehradun, India, **1945**.

[2] P.D. Dogra, Gymnosperms of India - II. Chilgoza pine (*Pinus geraradiana* Wall.). Bulletin No. 109. National Botanical Gardens Lucknow, India, **1964**.
[3] W.B. Critchfield and E.L. Little, Geographic distribution of the pines of the world (USDA Forest Service Miscellaneous Pub No 99, USA), **1966**.
[4] A. Farjon, Pines: Drawings and descriptions of the genus *Pinus*, (Antiquarian Booksellers Association of America Pub, New York), **1984**, p 220.
[5] A.Farjon, World checklist and bibliography of conifers (Royal Botanical Gardens Kew, Surrey, UK), **1998**, p 298.
[6] N.S. Thakur, S. Sharma and K.D. Sharma, Standardization of pre-treatments for chilgoza (*Pinus gerardiana*) nut drying, *J. Food Sci. Technol*., **2009**, 46**,** 142-145.
[7] N.K. Bansal and H.P. Garg, Solar crop drying. In: A.S. Mujumdar (Ed.), Advances in drying(Hemisphere Publishing Corporation, New York, USA,**1987**), p 279-343
[8] S. Sadasivam and A. Manickam, Biochemical methods, New Age International (P) Ltd, New Delhi, **1996**, 52-56.
[9] S.K. Thimmaiah, Standard methods of biochemical analysis, Kalyani Pub, New Delhi, **1999**, 82-83.
[10] S. Ranganna, Handbook of analysis and quality control for fruit and vegetable products, Tata McGraw Hill Pub Co Ltd, New Delhi, **1986**, 2nd edn., p 7-12, 623- 627.
[11] M.O. Mahony, Sensory evaluation of food: Statistical methods and procedures, Marcel Dekker, New York, **1985**, p 168-169.
[12] R. Cochran and C. Cox, Experimental designs, John Wiley and Sons, New York, **1967**, p 171-217.
[13] M.S. Butt, M. Nasir, S. Akhtar and K. Sharif, Effect of moisture and packaging on the shelf life of wheat flour, *Int. J. Food Safety*, **2004**, 4, 1-6.
[14] W.E. Brown, Plastics in food packaging properties: Design and fabrication, Marcel Dekker New York, **1992**, p. 293- 396.
[15] P.F. Fellow and B. Axtell, Appropriate food packaging: Transfer of technology for development, Amsterdam International Labour Office, Geneva, **1993,** p. 45-56.
[16] S.B. Kosoko, L.O Sanni, A.A. Adebowale, A.O. Daramola and M.O. Oyelakin, *African J. Food Sci.*, **2009,** 3**,**156-164.
[17] M. Venkatachalam and S.K. Sathe, *J. Agric. Food Chem*., **2006**, 54, 4705-4714.
[18] Anonymous, Shelf life of foods- Guidelines for its determination and prediction. Institute of Food Science and Technology, London, 1993.
[19] A.R. Malik and G.S. Shamet, *Res. J. Seed Sci*., **2009**, 2, 48-55.
[20] G.P. Savage, P.C. Dutta and D.L. Mc Neil, *J. Amer. Oil Chemist's Soc.*, **1999**, 9, 1059-1063.
[21] A. Kita and A. Figiel, *Acta Agrophysica*, **2007**, 9, 69-78.
[22] F. Tao, H. Gao, H. Chen, W. Chen, L. Song and L. Ge, *Acta Horticulturae*, **2007**, 804.
[23] A.Severini, T. De Pilli, A. Baiano and T. Gomes, *J. Food Proces. Preserv.*, **2003**, 27**,** 321- 335.
[24] J.L. Kinderlerer and S. Johnson, J. *Sci. Food Agric*., 1992, **58,** 89-93.
[25] J.S. Bonvehi and F.V. Coll, *Food Chem.***, 1993**, 48**,** 237- 241.
[26] A.S. Pershern, W.M. Breene and C. Lulai**,** *J. Food Proces. Preserv.*, **1995**, *19***,**9-26.