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RESEARCH ARTICLE

Effect of drying and packaging on storability of stevia leaves (*Stevia rebaudiana* Bertoni)

Gagandeep Kaur[1*] (LM-7767), Manoj Bansal[2], Preeti Birwal[3]

[1]Principal Scientist; [2] Ex M.Tech. Student; [3]Scientist, Department of Processing and Food Engineering, Punjab Agricultural University, Ludhiana, India.

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ABSTRACT: Fresh stevia leaves (*Stevia rebaudiana* Bertoni) were dried by open sun drying, mechanical drying at 50, 60 and 70°C and green house (simple and with north wall reflection) drying methods. The dried samples were packaged in airtight high density polyethene (HDPE) and polyethylene terephthalate (PET) jars and stored at ambient conditions. The effect of drying and packaging on storability were evaluated on the basis of quality parameters such as colour, total soluble solids (TSS), total sugar, ash and moisture content. It was observed from the study that the fresh stevia leaves dried by mechanical drying at 60° for 210 min, packaged in HDPE package can be stored under ambient condition for more than three months as the quality was maintained with moisture content (9.43%); total sugar (8.88%); ash content (6.76%); total soluble solids (9.79%) and overall acceptability (78±2.49%). Packaging material, storage period, storage condition and drying method had a significant effect on the different quality parameters and shelf life of stevia leaves.

1. INTRODUCTION

Stevia, botanically known as *Stevia rebaudiana* Bertoni is a sweet herb. The sweetening potency of stevioside and rebaudiside A are 250-300 and 350-400 times of sucrose, respectively (Ahmed *et al.,* 2011). In India, stevia has a good market potential and is successfully cultivated in the recent years in many parts of Rajasthan, Maharashtra, Kerala, Orissa and Punjab. In the past few years, a significant increase in case of diet-dependent diseases like diabetes, obesity, cardiovascular diseases, cancer and dental problem have been reported due to improper diet and of high sugar content (Anton *et al.,* 2010). An attention has been paid on stevia as an alternative to cane sugar (Thomas and Glade, 2010; Yadav *et al*., 2011). Stevia has a number of therapeutic benefits like regulating the blood sugar (Anton *et al.,* 2010), preventing hypertension (Dyrskog *et al.,* 2005), treatment of skin disorder and prevent tooth decay but also has religious importance. Stevia is house of high anti-fungal and anti-bacterial property (Tomita *et al.,* 1997).

**Corresponding Author:* Gagandeep Kaur
**E-mail: gagandeep@pau.edu*

As the fresh leaves are perishable in nature and get spoiled due to improper handling, growth of microorganisms, action of naturally occurring enzymes, chemical reactions and structural changes during storage. For the prevention of crop from deterioration and for increasing its shelf life, various preservation methods are employed (Singh and Kaur, 2015; Sangha and Kaur, 2020). A major goal of food processing is to convert perishable commodities into stable products that can be stored for extended periods thereby reducing losses and making them available at the time of shortage and off-season for use at places away from production site. In the previous studies, the effect of drying method and layer thickness on the drying behavior of stevia of leaves and the acceptability of five drying models to predict the drying pattern of stevia were studied (Kumar and Kaur, 2012; Bansal *et al.,* 2015). These results encouraged to study the effect of drying methods on storability and quality of stevia leaves and with the aim of increasing the shelf life of the leaves, this study has been undertaken.

2. MATERIALS AND METHODS

2.1. Preparation of Sample

Fresh stevia leaves were procured from the local farmers of Ludhiana, Punjab. Average dimension (length) of leaves were 1.5±0.9 cm. Based on review literature four different

methods were selected to dry fresh cleaned leaves *viz*., sun drying, green house drying, green house with north wall reflection drying (GHNWR) and mechanical tray drying at 50, 60 and 70ºC by varying the thickness of layer as 1, 1.5 and 2 cm. After preliminary analysis, the samples dried at 1.5 cm thickness of layer was selected for storage studies. The study was conducted in triplicate. Dried leaves were packaged in HDPE pouches of 19.3 x 10.6 cm size with 30 micron thickness and in airtight PET jars of 7 cm diameter and 6 cm height. The samples were stored at ambient conditions for 90 days. The experiment was conducted during the months of January to March, where the average temperature and relative humidity were in the range of 15-41°C and 23-37%, respectively.

2.2. Determination of Quality Parameters

The dried stevia leaves was estimated for the various quality parameters *viz*., moisture content, ash content, colour, total sugars and total soluble solids.

2.2.1. Moisture content and total sugars

The moisture content was estimated by standard oven method (AOAC, 2000) and expressed on dry basis. The sugar content estimated by taking protein free extract was prepared with ethanol extraction and mixed with phenol and sulphuric acid which resulted in brown colour mixture. The colour was measured at 490 nm (Dubois *et al.,* 1956). The concentration of total sugar (as glucose) was calculated from the standard glucose curve (20-100 mg/ml) using the following relationship.

$$\text{Total sugars (\%)} = \frac{\text{Sugar value from graph } (mg) \times \text{Total volume of extract (ml)}}{\text{Aliquot of the sample used (ml)} \times \text{Weight of sample}} \times 100 \quad ...(1)$$

The total soluble solids were determined with the help of a hand Refractometer (Erma, 0-32º Brix). One or two drops of the leaf extract obtained by crushing the leaves in a pestle and mortar, were put on the sample plate and the total soluble solids (in %) was read. The reading was normalized against a standard temperature of 20°C (AOAC, 1970).

2.2.2. Determination of colour

Colour was determined using Hunter Lab Miniscan XE Plus Colourmeter. The Colourmeter was calibrated as per procedure using standard white and black plates. The sample was filled in petridish and ensured no light is allowed to pass during the measuring process. The values L, a and b were measured (Baskaran *et al.,* 2002) and the colour change was determined using the formula (Eq. 3):

$$\text{Colour change } \Delta E = \sqrt{(\Delta L^2 + \Delta a^2 + \Delta b^2)} \quad ...(2)$$

where ΔL, Δa and Δb are deviations from 'L', 'a' and 'b' values of fresh sample.

2.2.3. Ash content

About 3-5 g of dried leaf sample was taken in a crucible and heated over low bunsen flame with lid half covered till fumes are no longer produced. The pre-heated crucible with sample was placed in a furnace and heated at 550°C for overnight. After cooling the furnace, the content was weighed and the ash content was calculated using the following relationship (AOAC, 1999).

$$\text{Ash content (\%)} = \text{Weight of ash} \times 100 / \text{Weight of sample} \quad ...(3)$$

2.3. Sensory Evaluation of Dried Stevia Leaves

Organoleptic quality of dried stevia leaf was conducted on a 9-point hedonic scale. Semi-trained panel of ten judges of age 20-50 years, with equal male - female proportion was used for the evaluation. The samples were evaluated in terms of appearance, colour, taste and overall acceptability. Overall acceptability was evaluated as an average of colour, appearance and taste is expressed in percentage. The average scores of all the 10 panelists were computed for different characteristics.

2.4. Statistical Analysis

The data were analyzed statistically by using univariate analysis of variance (UNI-ANOVA) in general linear model using Statistical Package for Social Sciences (SPSS, version 11.5). Analysis was done considering the main effects and then interactions. Means were computed and tested at 5% level of significance

3. RESULTS AND DISCUSSION

3.1. Moisture Content

The change in moisture content with respect to storage period for high density polyethylene (HDPE) poly pack and PET jars is shown in Fig. 1. It was observed that the moisture content increased with increase in storage days in both the storage packs and in all the drying methods. Similar results were found for dried ginger flakes (Kaur, 2011). It was observed that mechanical dried product has lower initial moisture content than sun dried and green house dried samples. The lowest moisture content observed was 12.62 and 11.11% (d.b.) for HDPE poly pouch and 10.49 and 9.43% (d.b.) for PET jars at 70 and 60°C drying temperature, respectively. The univarient ANOVA has been observed on the data obtained for both package and storage condition. The R^2 value was 0.994 (adjusted R^2 = 0.991) and it was observed that there is significant effect of packaging material, storage period and combined effect of packaging material and storage

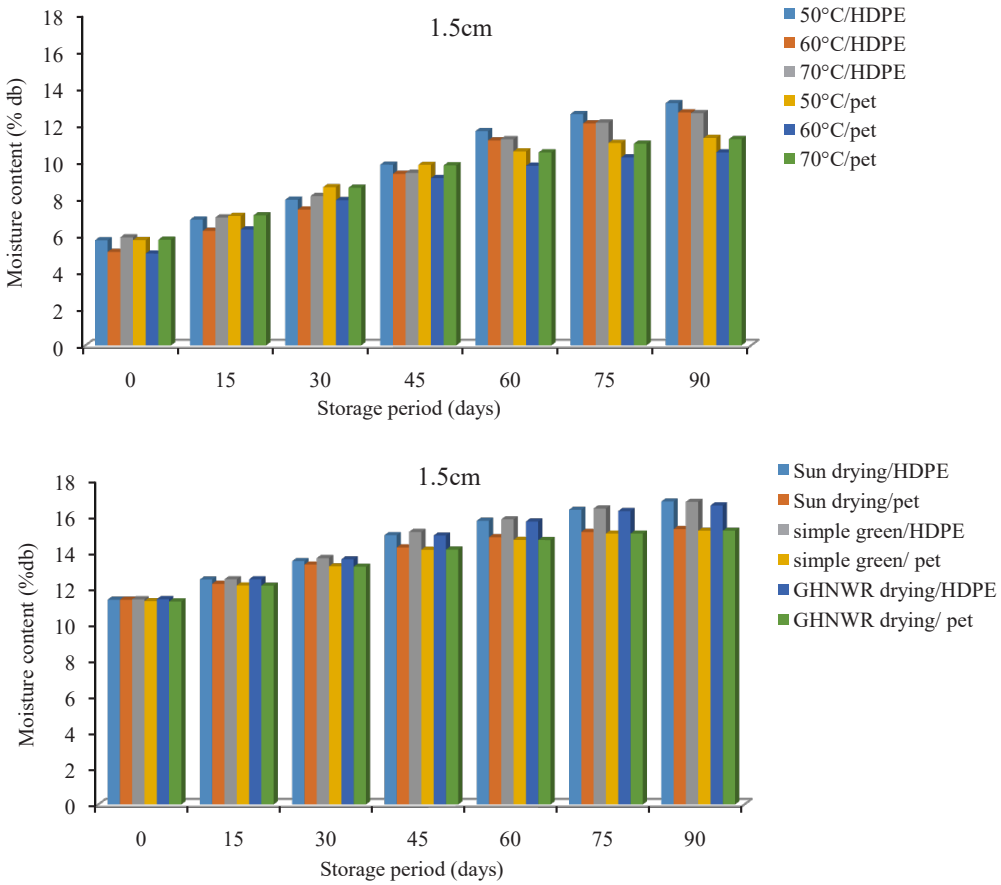

Fig. 1. Effcet of drying methods and pacakging materials on moisture content of stevia leaves with storage period.

period on moisture content as shown in Table 1. F value for storage, package and moisture content is 1.138. Muller *et al.* (1989) also observed moisture content of 11% (d.b.) after drying herbs and medicinal plant by green house type solar dryer.

3.2. Change in Colour

Colour is an important quality criteria in foods and agricultural products. Undesirable changes in colour of a food material may leads to a decrease in its quality and marketing value. During drying of stevia leaves, important modification in colour was noted. The drying method influenced the parameters 'L', 'a' and 'b' and the change in colour with respect to storage period and different packaging material is shown in Fig. 2. It was observed that during storage change in colour was observed for all the samples. In both packaging materials the change in colour was more pronounced in initial days than in final days of storage. The R^2 value observed for colour by ANOVA analysis was 0.994 (adjusted R^2 = 0.990) (Table 1). Therdthai and Zhou (2009) also observed that low temperature drying has less effect on colour. It was observed that there is significant effect of packaging material and storage period and combined effect of packaging materials and storage period on change in colour.

3.3. Ash Content

The change in ash content with respect to storage period for HDPE poly pack and PET jars is shown in Fig. 3. It was observed that the ash content decreased with increase in storage days for all the samples. This was due to the change in moisture content in product during storage. As the moisture content changed, the bone-dry matter content also changed with their respective moisture content during storage, this results in decrease in ash content. After 90 days of storage the ash content of samples were 5.79 and 5.58% at 50°C, 6.11 and 5.88% at 60°C and 8.25 and 8.03% at 70°C for HDPE poly pouch and PET jars, respectively. The data obtained for both packages were analyzed using univariant ANOVA. The R^2 value was 0.994 (adjusted R^2=0.991) and it was observed from Table 1 that there is significant effect of storage period, packaging materials and combined effect of packaging material and storage period on ash content. Thus HDPE poly pouch is found as the best packaging material with

Table 1.
Mean comparison for physico-chemical properties of dried stevia leaves after 90 days of storage.

Method of drying and temperature	Quality / sensory parameters											
	Moisture content, % (d.b.)		Colour		Ash		Total sugars		Total soluble solids		Overall acceptability	
	Storage method		Storage method		Storage method		Storage method		Storage method		Storage method	
	PET	HDPE	PET	HDPE	PET	HDPE	PET	HDPE	PET	HDPE	PET	HDPE
Mechanical drying - 50°C	11.27±0.3^{cA}	13.16±0.4^{cB}	10.46±0.11^{deB}	7.53±0.4^{dA}	5.58±0.61^{cdA}	5.79±0.58^{aA}	8.17±0.27^{abA}	7.94±0.23^{aA}	21.00±0.19^{cA}	21.50±0.24^{cB}	67.00±0.24^{aA}	67.00±0.33^{aA}
Mechanical drying - 60°C	9.43±0.78^{aA}	11.11±0.92^{aB}	9.79±0.63^{dB}	6.78±0.71^{dA}	6.76±0.51^{dA}	6.67±0.53^{dA}	8.88±0.42^{cB}	8.34±0.25^{bA}	20.00±0.21^{bA}	20.00±0.22^{bB}	78.00±2.19^{bB}	75.00±1.9^{cA}
Mechanical drying - 70°C	10.49±0.11^{bA}	12.62±0.3^{bB}	3.61±0.1$^{b\,B}$	1.65±0.41^{abA}	8.03±0.21^{eA}	8.25±0.43^{eA}	8.07±0.18^{aA}	8.09±0.35^{abA}	23.00±0.32^{eA}	23.00±0.38^{dB}	72.00±0.95^{bA}	72.00±0.88^{bA}
Open sun drying	15.28±0.23^{deA}	16.81±0.1^{dB}	2.87±0.22^{aB}	2.21±0.31^{bcA}	5.19±0.64^{aA}	5.58±0.29^{bA}	8.59±0.19^{bA}	8.59±0.71^{bcA}	19.00±0.41^{aA}	19.50±0.44^{aA}	67.00±1.2^{aA}	67.00±1.32^{aA}
Simple green house drying	15.19±0.12^{dA}	16.79±0.3^{dB}	5.86±0.^{1cB}	2.87±0.43^{cA}	5.38±0.32^{abA}	5.62±0.55^{bcA}	8.97±0.21^{cA}	8.97±0.69^{cdA}	21.50±0.24^{dA}	21.50±0.21^{cA}	89.00±1.7^{dB}	72.00±1.3^{bA}
Green house with north wall reflection drying	15.19±0.13^{dA}	16.59±0.5^{dB}	3.62±0.3^{bA}	1.36±0.18^{aB}	5.44±0.54^{bcA}	5.00±0.48^{aA}	8.65±0.31^{bA}	8.85±0.38^{cdA}	21.50± 0.12^{dA}	21.50±0.13^{cA}	78.00±2.6^{cB}	72.00±1.6^{bA}

Mean values ±SD Values in a row with different superscripts (in small alphabet) are significantly different between samples dried at different temperatures and techniques at p≤0.05
Values in a column with different superscripts (in capital alphabet) are significantly different packaging material at p≤0.05

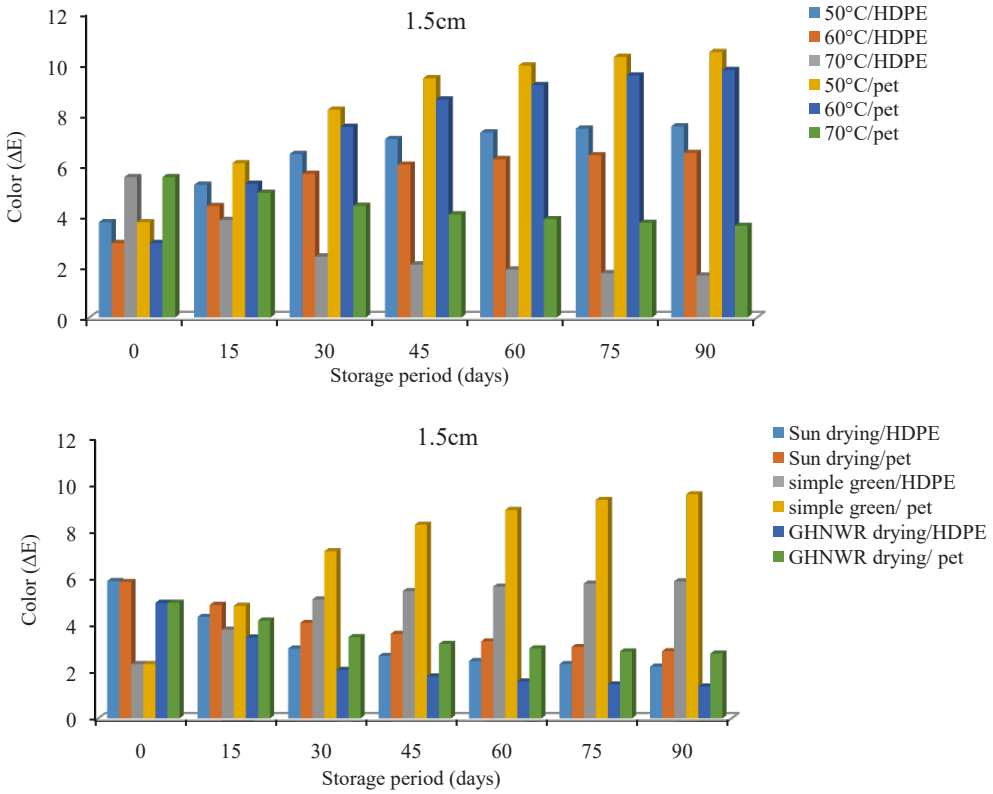

Fig. 2. Change in colour of stevia leaves with storage period as affecetd by drying methods and pacakging materials.

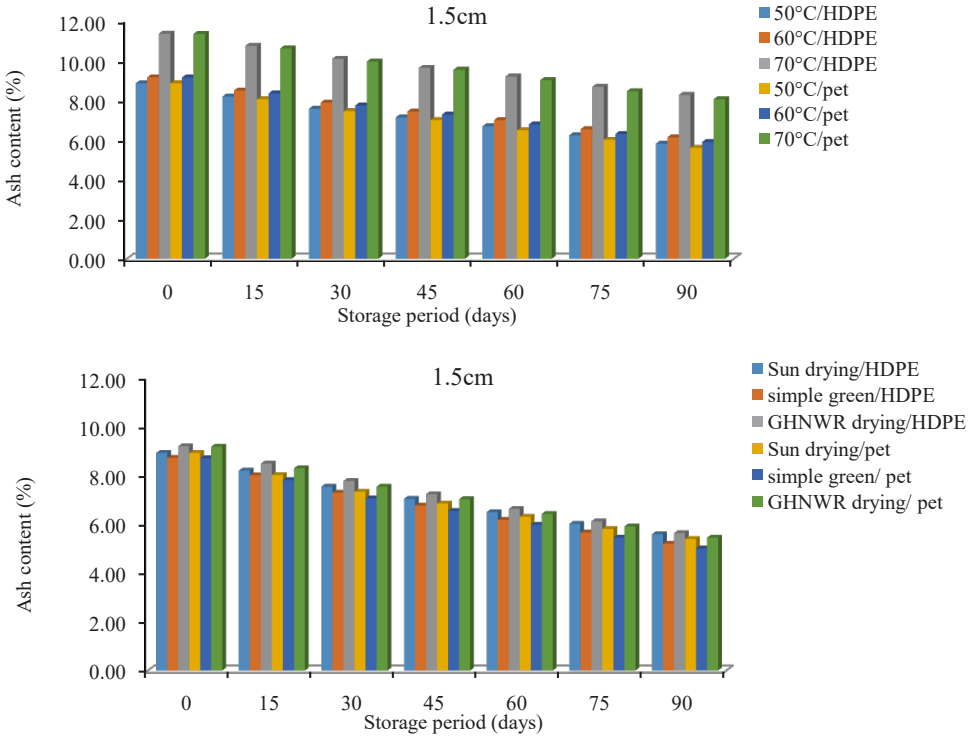

Fig. 3. Effcet of drying methods and pacakging materials on ash content of stevia leaves with storage period.

respect to ash content of dried leaves stored in ambient condition. Similar results were also reported by Gasmalla *et al.* (2014) for the dried stevia leaves.

3.4. Total Sugar Content

The total sugar content of fresh stevia leaves was 4.2%. Similar results were reported by Samsudin and Aziz (2013). The change in total sugar content with respect to storage period for different packaging material is shown in Fig. 4. The total sugar was approximately constant with increase in storage period for both the packaging material. During storage studies decrease in sugar content was observed for samples dried at 50, 60, 70°C, sun drying and simple green house drying for both packaging materials. The sugar content after 90 days of storage was in range of 7.94 to 8.17% for the samples dried at 50°C, 60ºC and 70ºC and stored in HDPE poly pouch and PET jars. The R^2 value observed in ANOVA was 0.998 (adjusted R^2=0.997) as given in Table 1. It was observed that there is significant effect of storage period on total sugar, but the effect of packaging materials, combined effect of packaging materials and storage period is non-significant.

3.5. Total Soluble Solids

The total soluble solid of fresh stevia leaves was 14°Brix. The change in total soluble solid with respect to storage period for HDPE poly pack and PET jars stored is shown in Fig. 5. It is observed that the total soluble solid was constant with increase in storage period in both packaging materials. The TSS of the dried samples after 90 days of storage was in the range of 20 to 23ºBrix for HDPE and PET jars. Whereas, the TSS value of samples dried by sun drying, simple green drying and GHNWR are in the range of 19 to 21ºBrix. Table 1 shows the R^2 value observed for total soluble solids by ANOVA analysis as 0.998 (adjusted R^2 = 0.996).

3.6. Sensory Evaluation

The relationship between the overall acceptability of dried stevia leaves and storage days for different packaging materials is shown in Fig. 6. It was observed that the sensory percentage was random during the storage period in both packaging materials. The overall acceptability of 78 was observed for samples dried at 60°C and green house with north wall reflection samples after 90 days of storage period. The lowest sensory percentage observed was 67

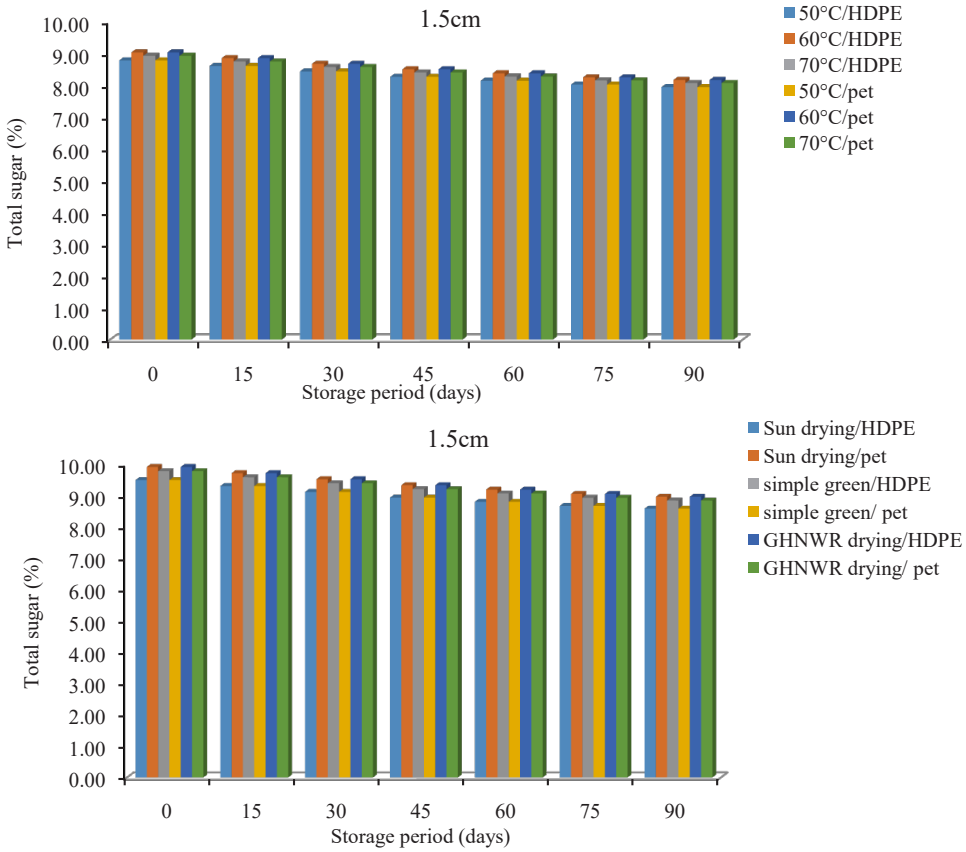

Fig. 4. Effcet of drying methods and pacakging methods on total sugar content of stevia leaves with storage period.

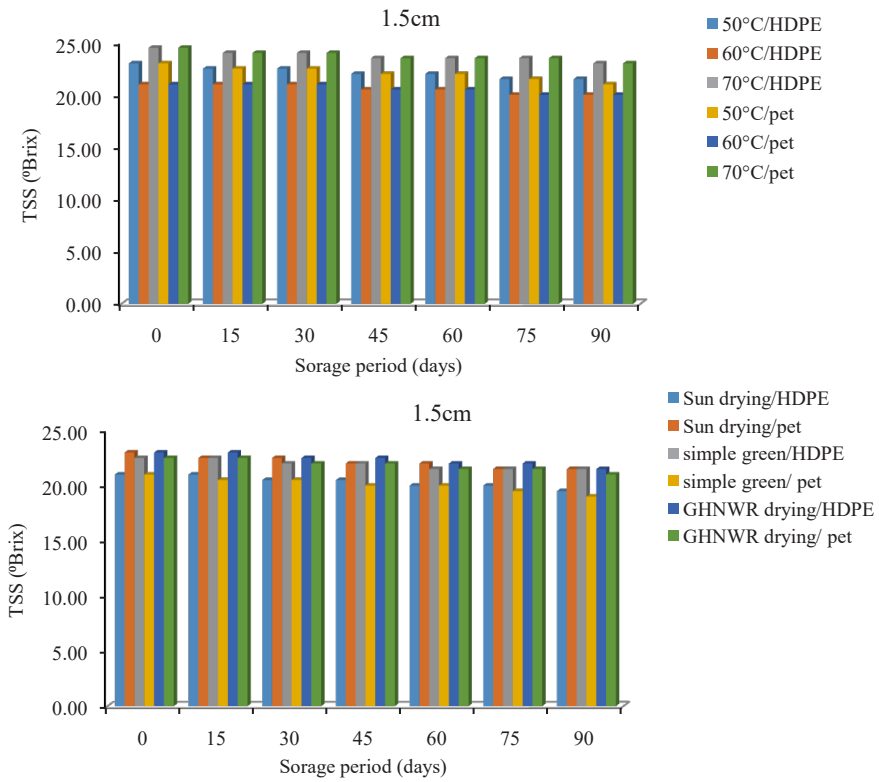

Fig. 5. Total soluble solids of stevia leaves with storage period as influenced by the drying methods and pacakging methods.

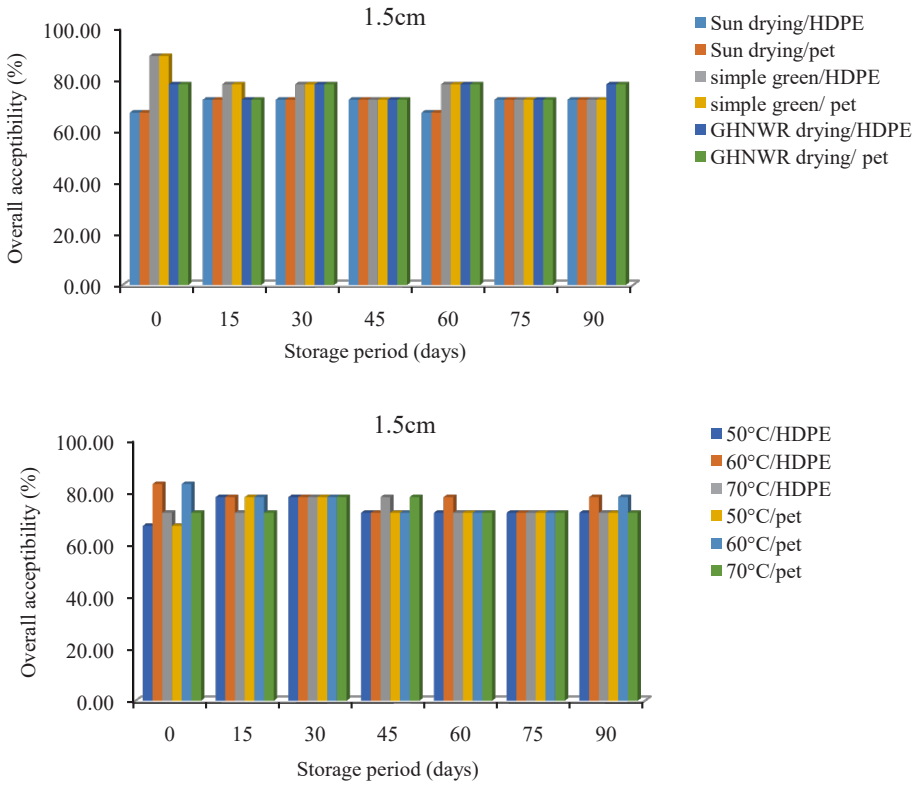

Fig. 6. Effect of drying methods and pacakging materials on overall acceptibiltiy of stevia leaves with storage period.

for 50°C and sun dried samples. The R^2 value observed by ANOVA analysis was 0.998 (adjusted R^2=0.996). It was observed that there is significant effect of packaging material, storage period on overall acceptability as presented in Table 1.

4. CONCLUSIONS

Significant effect of drying methods, packaging materials and storage period on quality parameters and shelf life of stevia leaves was observed. The lower the moisture content better was the colour with significant difference was observed in the PET jars. Low temperature drying is suitable for the stevia leaves.

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