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Interactive Effects of Wrapping Materials and Cold Storage Durations on Total Soluble Solids of Plum

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Abstract: Three wrapping materials (kraft paper + straw, kraft paper and news paper) and five cold storage durations (0, 8, 16, 24 and 32-day) were investigated for total soluble solids (TSS) of plum (cv. Shablon) during cold storage at -1°C temperature and 98% relative humidity. The experiment was laid out in Factorial Completely Randomized Design (FCRD) with four replications for each one of factors. The data collected were subjected to Analysis of Variance (ANOVA) and Duncan's Multiple Range Test (DMRT) at 1% probability was performed to compare the means of different treatments. The statistical results of the study indicated that although wrapping material had no significant effect ($P \leq 0.01$) on TSS, cold storage duration significantly ($P \leq 0.01$) affected it. Results of the study also indicated that TSS frequently decreased and increased by increasing cold storage duration. In addition, kraft paper + straw was the best wrapping materials for protecting TSS.

Key words: Plum · Wrapping material · Cold storage duration · Total soluble solids (TSS)

INTRODUCTION

A plum (*Prunus domestica*) is a drupe fruit of the genus *Prunus*. Fruits are usually of medium size, between 1 to 3 inches in diameter, globose to oval. The flesh is firm, juicy and mealy. The fruit's peel is smooth, with a natural waxy surface that adheres to the flesh. The fruit has a single large seed. Plum fruit tastes sweet and/or tart; the skin may be particularly tart. It is juicy and can be eaten fresh or used in jam-making or other recipes. Plums come in a wide variety of colors and sizes. Some are much firmer-fleshed than others and some have yellow, white, green or red flesh, with equally varying skin color [1]. Plums are produced around the world and China is the world's largest producer. The ten largest producers of plums are China, Romania, USA, Serbia, Chile, France, Iran, Turkey, Italy and India. Iran products nearly about 269,139 tons of plum and is ranked 7th in the world [2]. But, Iranian plums are not exported because of variability in size and shape and lack of suitable packaging [3].

Methods that are being used to preserve whole fruits and vegetables during storage and marketing are generally based on refrigeration with or without control of composition of the atmosphere [4, 5]. However, temperature, atmosphere, relative humidity and sanitation must be regulated to maintain quality of them [6, 7]. In this direction, several methods that have been used are refrigeration, controlled atmosphere packaging, modified atmosphere packaging and chemical preservatives [8-10]. The most prevalent method is rapid cooling at a low temperature with high relative humidity [11]. However, low temperature storage is not economically feasible in most developing countries [5, 12].

Fungicides control postharvest decay of whole fruits, but they leave residues that are potential risks to humans and the environment [12]. In addition, many consumers are suspicious of chemicals in their foods, especially in fruits and vegetables [9]. Sulfites were effective chemical preservative as they were both inhibitors of enzymatic browning and antimicrobial. But their use has been

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Fig. 1: Handheld refractometer

banned due to adverse reaction in consumers [9, 13]. Moreover, chemical preservatives affect the flavor of fruits and vegetables [14].

Coatings, films and wrapping materials are also effective in reducing desiccation (moisture loss), but are subject to microbial growth and disposal problems [10, 15]. Many years of research are conducted to develop a material that would cover fruit so that an internal modified atmosphere would develop [16, 17].

In this paper, the effect of wrapping material and cold storage duration on total soluble solids (TSS) of plum (cv. Shablon) during cold storage at -1°C temperature and 98% relative humidity is reported.

MATERIALS AND METHODS

Plant Materials: Plums (cv. Shablon) were purchased from a local market in Karaj, Iran. They were visually inspected for freedom of defects and blemishes. Plums were then wrapped in different wrapping materials (kraft paper + straw, kraft paper and news paper), placed in plastic boxes and stored in cold storage at -1°C temperature and 98% relative humidity for 0, 8, 16, 24 and 32 days.

Total Soluble Solids (TSS): The TSS of plums was measured using an ATC-1E handheld refractometer (ATAGO, Japan) at 20°C temperature (Fig. 1).

Statistical Analysis: The experiment was laid out in Factorial Completely Randomized Design (FCRD) with three wrapping materials (kraft paper + straw, kraft paper and news paper) and five cold storage durations (0, 8, 16, 24 and 32-day) at -1°C temperature and 98% relative humidity with four replications for each one of factors. The effect of the factors on TSS was determined by analysis of variance (ANOVA) using SPSS 12.0 (Version, 2003). Also, Duncan's Multiple Range Test (DMRT) at 1% probability was performed to compare the means of different treatments.

Table 1: Analysis of variance for total soluble solids of plum (cv. Shablon)

Source of variation	Degree of freedom	Mean square
Wrapping material	2	1.02 ^{ns}
Cold storage duration	4	10.8 **
Wrapping material × Cold storage duration	8	2.05 **
Error	45	0.25
C.V. (%)	---	3.54

** = Significant at 0.01 probability level

ns = Non-significant

Table 2: Means comparison for total soluble solids of plum (cv. Shablon) for different studied treatments using DMRT at 1% probability

	Treatment	TSS (%)
Wrapping material	Kraft paper + straw	14.39 a
	Kraft paper	14.16 ab
	News paper	13.94 b
Cold storage duration	0-day	14.07 b
	8-day	13.00 c
	16-day	14.17 b
	24-day	15.64 a
	32-day	13.94 b

Means in the same column with different letters differ significantly at 0.01 probability level according to DMRT

RESULTS AND DISCUSSION

Although wrapping material had no significant effect ($P \leq 0.01$) on TSS of plum, cold storage duration significantly ($P \leq 0.01$) affected it (Table 1). Anyway, the highest TSS of 14.39% was observed in kraft paper + straw and lowest (13.94%) in news paper and wrapping material affected TSS in the order of kraft paper + straw > kraft paper > news paper. Also, the highest TSS of 15.64% was observed in 24-day and lowest (13.00%) in 8-day and TSS frequently decreased and increased with increased cold storage duration (Table 2). Moreover, interaction of wrapping material × cold storage duration had significant effect ($P \leq 0.01$) on TSS (Table 1). The study of wrapping material and cold storage duration combinations on TSS showed that in kraft paper + straw, TSS had the highest value (15.75%) in 16-day and the lowest value (12.75%) in 8-day. Also, in kraft paper, TSS had the highest value (15.75%) in 24-day and the lowest value (12.88%) in 8-day.

Table 3: Means comparison for total soluble solids of plum (cv. Shablon) for combinations of wrapping material and cold storage duration using DMRT at 1% probability

Wrapping material ×	Cold storage duration	TSS (%)
Kraft paper + straw	0-day	14.07 bc
	8-day	12.75 f
	16-day	15.75 a
	24-day	15.63 a
	32-day	13.75 bcd
Kraft paper	0-day	14.07 bc
	8-day	12.88 ef
	16-day	13.63 cde
	24-day	15.75 a
	32-day	14.50 b
News paper	0-day	14.07 bc
	8-day	13.38 cdef
	16-day	13.13 def
	24-day	15.55 a
	32-day	13.56 cde

Means in the same column with different letters differ significantly at 0.01 probability level according to DMRT

Besides, in news paper, TSS had the highest value (15.55%) in 24-day and the lowest value (13.13%) in 16-day. In addition, the maximum mean value for TSS (15.75%) was observed in 16-day of kraft paper + straw and 24-day of kraft paper and the minimum mean value for TSS (12.75%) was observed in 8-day of kraft paper + straw (Table 3). These results are in agreement with those of Smith and Stow [4], Rashidi *et al*. [18] and Rashidi *et al*. [19] who concluded that coatings, films and wrapping materials significantly affected TSS. However, these results are not in line with the results reported by Park *et al*. [16, 17], Rashidi *et al*. [18], Rashidi *et al*. [19], Hussain *et al*. [20], Bahri *et al*. [21] and Niari *et al*. [22] that TSS significantly increased by increasing cold storage duration.

CONCLUSION

Although wrapping material had no significant effect ($P \leq 0.01$) on TSS, cold storage duration significantly ($P \leq 0.01$) affected it. Results of the study also indicated that TSS frequently decreased and increased by increasing cold storage duration. In addition, kraft paper + straw was the best wrapping materials for protecting TSS.

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