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Interactive Effects of Wrapping Materials and Cold Storage Durations on Water Content of Apple

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Abstract: This study was conducted on the interactive effects of wrapping materials and cold storage durations on water content of apple (cv. Golden Delicious) during cold storage at -1°C temperature and 90% relative humidity. Four wrapping methods (news paper, kraft paper, kraft paper + straw and without wrapping) and five cold storage durations (0, 15, 30, 45 and 60-day) were investigated. 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) was performed to compare the means of different treatments. The statistical results of the study indicated that wrapping material and cold storage duration significantly ($P \leq 0.01$) affected water content of apple. Results of the study also indicated that kraft paper + straw was the best wrapping material for water content. In addition, water content of apple decreased by increasing cold storage duration.

Key words: Apple · Wrapping material · Cold storage duration · Water content

INTRODUCTION

There are more than 7,500 known cultivars of apples, resulting in a range of desired characteristics. Different cultivars are bred for various tastes and uses, including cooking, eating raw and cider production. Apples are generally propagated by grafting, although wild apples grow readily from seed. They are often eaten raw, but can also be found in many prepared foods (especially desserts) and drinks [1]. About 63 million tones of apples were grown worldwide in 2012, with China producing almost half of this total. The United States is the second-leading producer, with more than 6% of world production. The largest exporters of apples in 2009 were China, U.S., Turkey, Poland, Italy, Iran and India while the biggest importers in the same year were Russia, Germany, the UK and the Netherlands [2]. The Golden Delicious is a cultivar of apple with a yellow color, not closely related to the Red Delicious apple. According to the US Apple Association website it is one of the fifteen most popular apple cultivars in the United States. Golden Delicious is a large, yellowish-green skinned cultivar and very sweet to the taste. It is prone to bruising and shriveling, so it needs careful handling and storage. It is a favorite for salads, apple sauce and apple butter [1].

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 [3, 4]. However, temperature, atmosphere, relative humidity and sanitation must be regulated to maintain quality of them [5, 6]. In this direction, several methods that have been used are refrigeration, controlled atmosphere packaging, modified atmosphere packaging and chemical preservatives [7-9]. The most prevalent method is rapid cooling at a low temperature with high relative humidity [10]. However, low temperature storage is not economically feasible in most developing countries [4, 11].

Fungicides control postharvest decay of whole fruits, but they leave residues that are potential risks to humans and the environment [11]. In addition, many consumers are suspicious of chemicals in their foods, especially in fruits and vegetables [8]. Sulfites were effective chemical preservative as they were both inhibitors of enzymatic

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browning and antimicrobial. But their use has been banned due to adverse reaction in consumers [8, 12]. Moreover, chemical preservatives affect the flavor of fruits and vegetables [13].

Coatings, films and wrapping materials are also effective in reducing desiccation (moisture loss), but are subject to microbial growth and disposal problems [9, 14]. Many years of research are conducted to develop a material that would cover fruit so that an internal modified atmosphere would develop [15, 16].

In this paper, the interactive effects of wrapping materials and cold storage durations on water content of apple (cv. Golden Delicious) during cold storage at -1°C temperature and 90% relative humidity is reported.

MATERIALS AND METHODS

Plant Materials: Apples (cv. Golden Delicious) were purchased from a local market in Karaj, Iran. They were visually inspected for freedom of defects and blemishes. Apples were then wrapped in different wrapping materials (news paper, kraft paper, kraft paper + straw and without wrapping), placed in plastic boxes and stored in cold storage at -1°C temperature and 90% relative humidity for 0, 15, 30, 45 and 60 days.

Water Content: The water content of apples was determined using the equation (1):

$$\text{Water content (\%)} = 100 \times (M_1\text{-}M_2)/M_1 \quad (1)$$

where:
M_1 = Mass of sample before drying, g
M_2 = Mass of sample after drying, g

Statistical Analysis: The experiment was laid out in Factorial Completely Randomized Design (FCRD) with four wrapping methods (news paper, kraft paper, kraft paper + straw and without wrapping) and five cold storage durations (0, 15, 30, 45 and 60-day) at -1°C temperature and 90% relative humidity with four replications for each one of factors. The effect of the factors on water content of apple 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 water content of apple (cv. Golden Delicious)

Source of variation	Degree of freedom	Mean square
Wrapping material	3	0.30 **
Cold storage duration	4	2.58 **
Wrapping material × Cold storage duration	12	0.03 ^{ns}
Error	42	0.10
C.V. (%)	---	0.37

** = Significant at 0.01 probability level
ns = Non-significant

Table 2: Means comparison for water content of apple (cv. Golden Delicious) for different studied treatments using DMRT at 1% probability

Treatment		Water content (%)
Wrapping material	No wrapping	85.44 b
	News paper	85.66 a
	Kraft paper	85.78 a
	Kraft paper + straw	85.85 a
Cold storage duration	0-day	86.50 a
	15-day	86.00 b
	30-day	85.64 c
	45-day	85.33 d
	60-day	85.16 d

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

RESULTS AND DISCUSSION

Wrapping material and cold storage duration significantly ($P \leq 0.01$) affected water content of apple (Table 1). The highest water content of 85.85% was observed in kraft paper + straw and lowest (85.44%) in no wrapping method and wrapping material affected water content in the order of kraft paper + straw > kraft paper > news paper > no wrapping. Also, the highest water content of 86.50% was observed in 0-day and lowest (85.16%) in 60-day and water content decreased with increased cold storage duration (Table 2). Moreover, interaction of wrapping material × cold storage duration had no significant effect on water content (Table 1). The study of wrapping material and cold storage duration combinations on water content indicated that in each wrapping method, water content had the highest value in 0-day and the lowest value in 60-day. In addition, the maximum mean value for water content (86.50%) was observed in 0-day of all wrapping methods and the minimum mean value for water content (84.70%) was observed in 60-day of no wrapping method. Furthermore, water content in each wrapping method decreased with increased cold storage duration (Table 3). These results are in agreement with those of Mahmoud and Savello [17],

Table 3: Means comparison for water content of apple (cv. Golden Delicious) for combinations of wrapping material and cold storage duration using DMRT at 1% probability

Wrapping material × Cold storage duration		Water content (%)
No wrapping	0-day	86.50 a
	15-day	85.80 bcde
	30-day	85.30 efgh
	45-day	84.90 hi
	60-day	84.70 I
News paper	0-day	86.50 a
	15-day	86.00 abc
	30-day	85.60 bcdefg
	45-day	85.28 fgh
	60-day	85.13 ghi
Kraft paper	0-day	86.50 a
	15-day	86.05 abc
	30-day	85.75 bcdef
	45-day	85.48 defg
	60-day	85.30 efgh
Kraft paper + straw	0-day	86.50 a
	15-day	86.10 ab
	30-day	85.83 bcd
	45-day	85.58 cdefg
	60-day	85.40 defgh

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

Avena-Bustillos *et al*. [18], Rashidi *et al*. [19] and Rashidi *et al*. [20] who concluded that coatings, films and wrapping materials significantly conserved water content. These results are also in line with the results reported by Smith and Stow [3], Baldwin *et al*. [8], Rashidi *et al*. [19], Rashidi *et al*. [20], El Ghaouth *et al*. [21], Bahri *et al*. [22] and Niari *et al*. [23] that water content significantly decreased with increased cold storage duration.

CONCLUSION

Wrapping material and cold storage duration significantly ($P \leq 0.01$) affected water content of apple. Results of the study indicated that kraft paper + straw was the best wrapping material for conserving water content of apple. In addition, water content of apple decreased by increasing cold storage duration.

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