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The Effect of Modified Atmosphere Packaging on Physicochemical, Microbial, and Sensorial Properties of Iranian Mazafati Date

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HIGHLIGHTS

- Acidity, Brix, and microbial loads in the Modified Atmosphere Packaging (MAP) groups were lower than control group.
- The MAP group at 5 °C and control group at 25 °C had the highest and lowest sensorial scores, respectively.
- Application of the MAP method along with low temperature can increase the shelf-life of Mazafati dates.

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Acronyms and abbreviations
MAP=Modified Atmosphere Packaging
CFU=Colony Forming Unit

ABSTRACT

Background: Modified Atmosphere Packaging (MAP) is one of the most convenient packaging methods that could be useful in reducing the wastes and extending the crops' shelf-life. This research aimed to assess the impact of MAP containing high concentrations of carbon dioxide on physicochemical, microbial, and sensorial properties of Iranian Mazafati date.

Methods: Date samples were packed separately in control and MAP treatment groups and stored at 5 and 25 °C. After 30, 60, and 90 storage days, acidity, Brix index, total count of bacteria, molds, and yeast, texture hardness, wettability, flavor, color changes of samples were evaluated. The data were analyzed by MSTAT-C software.

Results: Acidity, Brix, and microbial loads in the MAP treatment groups were significantly (p<0.05) lower than control group. Hardness values of the date samples were significantly (p<0.05) decreased during 30, 60, and 90 days of storage time using MAP with low temperature. The MAP group at 5 °C and control group at 25 °C had the highest and lowest sensorial scores, respectively showing significant differences (p<0.05).

Conclusion: The results of this study showed that application of the MAP method along with low temperature increases the shelf-life of Iranian Mazafati dates.

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Introduction

In recent years, global production of dates has increased, so that the date production rate has been doubled and reached to eight million tons from 1991 to 2010 (Manickavasagan et al., 2012). Palm trees are well adapted to desert environments characterized by high temperature and lack of water. Dates are considered as the main fruit in arid and semi-arid areas, especially in South Africa and West Asia countries such as Iran which is one of the largest producers of dates in the world. Several date cultivars are produced in Iran especially Mazafati which is a popular cultivar grown mainly in southern regions of the country (Kader and Hussein, 2009).

Modified Atmosphere Packaging (MAP) is one of the convenient packaging methods that could be useful in reducing the wastes and extending the crops' shelf-life.

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Presumably, MAP of dates reduces the presence of mold and insects, sugar crystals' formation, color changes, peeling, and water activity. MAP reduces respiratory intensity and delays the fruits' softening and ripening. Increase of the carbon dioxide concentration leads to anaerobic respiration and accumulation of ethanol in fruits. MAP system leads to long shelf-life while maintaining the desirable qualitative properties (Caleb et al., 2012; Sandhya, 2010).

One of the main reasons for the waste of dates in Iran is inappropriate packaging and maintenance under unsuitable conditions. So, this research aimed to assess the impact of MAP containing high concentrations of carbon dioxide on physicochemical, microbial, and also sensorial properties of Iranian Mazafati date.

Materials and methods

Experiments

The Mazafati date samples were harvested from palm trees grown around Bam area, Kerman province, Southern Iran. After mixing the samples, they were randomly packed in 48 packages. The samples were packed in specific packaging bags with a thickness of 50 µm under modified atmosphere using a packaging machine that created a vacuum condition by applying a gas injection machine (A200 Model; Henkelman, Germany). Gas combination of packages were adjusted with 20% of carbon dioxide and 80% of nitrogen using carbon dioxide gas transmission rate of 1.470 $m^{-2}d^{-1}atm^{-1}$ at 25 °C and water vapor transmission rate equal to 2.3×10^{-3} kg $m^{-2}s^{-1}pa^{-1}$ at 38 °C. Each package was filled with 20 dates under the stated conditions and kept at two temperatures of 5 and 25 °C inside the refrigerated incubator (Achour et al., 2003). The samples stored in non-MAP (usual) package were considered as control group. After 30, 60, and 90 days of storage, all samples were subjected to physicochemical, microbial, and sensorial tests.

Acidity and Brix measurement

A homogeneous sample was prepared from 10 date fruits for measuring total suspended solids and acidity. Five g of fruit (including skin and flesh) was mixed with 10 ml of distilled water by blender and then, it was centrifuged. In the next step, level of total suspended solids was measured in supernatant as Brix percentage in fruit juice using a refractometer. Titratable acidity was evaluated in fruit juice by titrating with 0.1 N sodium hydroxide in the presence of phenolphthalein as an indicator and the results were expressed as a percentage of malic acid according to AL-Qurashi and Awad (2011).

Total microbial count

Twenty-five g of kernel date was mixed with 225 ml of sterilized Ringer's solution in a stomacher bag for 1 min. Total bacterial count was performed through the agar plate count medium and pour plate methods. The number of yeasts and molds were counted by Yeast Extract Glucose Chloramphenicol Agar and surface culture method (Robinson, 2014). Meanwhile, all the consumed media were obtained from Merck-Darmstadt Company, Germany.

Texture changes of the samples

In order to determination of hardness, the samples were compressed in a one-cycle compression–decompression test at a constant speed of 50 mm/min using a 50 mm diameter cylindrical probe (Nourian et al., 2003).

Sensorial analysis

Sensory-descriptive test was conducted to measure the sensorial factors. To this purpose, 15 well-trained evaluators assessed the samples. The characteristics of dates such as wettability, color, and flavor were scored through a 100-mm linier hedonic scale from 0 to 100 (100=like extremely, 1=dislike extremely) according to Ma et al. (2017).

Statistical analysis

One-way analysis of variance and Duncan's multiple tests was conducted to compare the groups. The data were analyzed by MSTAT-C software version 14.2.

Results

Values of the studied physicochemical, microbial, and sensorial properties in control and MAP treatment groups are indicated in Table 1. Acidity, Brix, and microbial loads in the MAP treatment groups were significantly (p<0.05) lower than control group. Hardness values of the date samples were significantly (p<0.05) decreased during 30, 60, and 90 days of storage time using MAP with low temperature (data not shown).

The MAP group at 5 °C and control group at 25 °C had the highest and lowest sensorial scores, respectively showing significant differences (p<0.05). At the end of 90-day storage, the mean wettability score of MAP group at 5 °C and control group at 25 °C were 75 and 55, respectively according to the 100-point hedonic scale analysis (Figure 1); these values for color score were 80 and 55, respectively (Figure 2). Also, the mean flavor score was 63.3 for MAP group at 5 °C, and 45 for control group at 25 °C (Figure 3).

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Table 1: Mean values of the studied physicochemical, microbial, and sensorial properties in control and modified atmosphere packaged treatment groups in various storage days

Source	Time		Packaging		Temperature		AB		AC		BC		ABC	
Acidity (Meq/g)	0.033	S	0.010	S*	0.005	S	0.001	S	0.001	S	0.000	NS	0.000	S
Wettability	111.28	S	0.13	S	20.67	S	6.68	S	3.06	NS	0.88	NS	0.15	NS
Brix (%)	194.30	S	184.08	S	42.18	S	11.86	S	4.18	S	58.52	S	6.74	S
Hardness (N/mm)	10.82	S	6.52	S	0.82	S	1.62	S	0.17	S	0.047	NS	0.038	NS
Total count (CFU/g)	4.7×10^{6}	S	1.008×10^{7}	S	8×10^{6}	S	1.6×10^{6}	S	1.3×10^{6}	S	4.7×10^{6}	S	1.07×10^{6}	S
Mold/yeast (CFU/g)	3.3×10^{5}	S	1.8×10^{5}	S	4.9×10^{5}	S	3.7×10^{5}	S	6.7×10^{5}	S	1.3×10^{5}	S	2.4×10^{4}	S
Flavor	521.35	S	567.18	S	188.02	S	56.07	S	35.24	S	117.18	NS	19.965	NS
Color	326.96	S	402.52	NS**	17.52	NS	247.24	S	48.91	S	31.68	S	6.41	S
Freedom degree	3		1		1		3		3		1		3	

AB: Time and Packaging
AC: Time and Temperature
BC: Packaging and Temperature
ABC: Time , Packaging and Temperature
*S: Significant
**NS: Not Significant

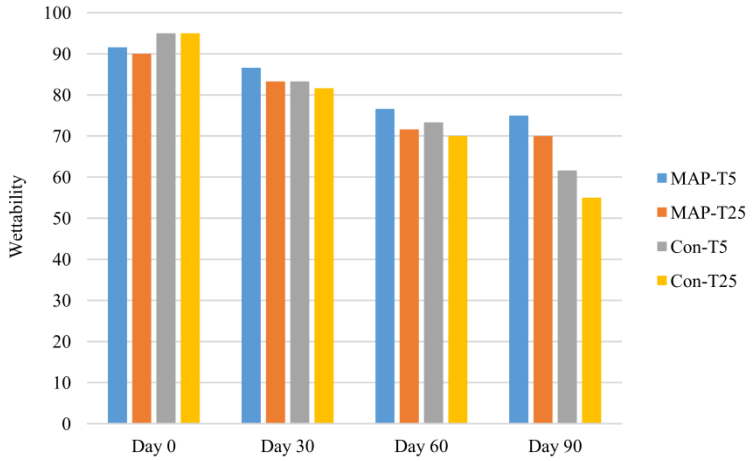


Figure 1: Mean wettability scores of date samples according to the 100-point hedonic scale analysis in control and modified atmosphere packaging groups (MAP-T5: modified atmosphere packaging group stored at 5 ℃; MAP-T25: modified atmosphere packaging group stored at 25 ℃; Con-T5: control group with usual packaging stored at 5 ℃; Con-T25: control group with usual packaging stored at 25 ℃)

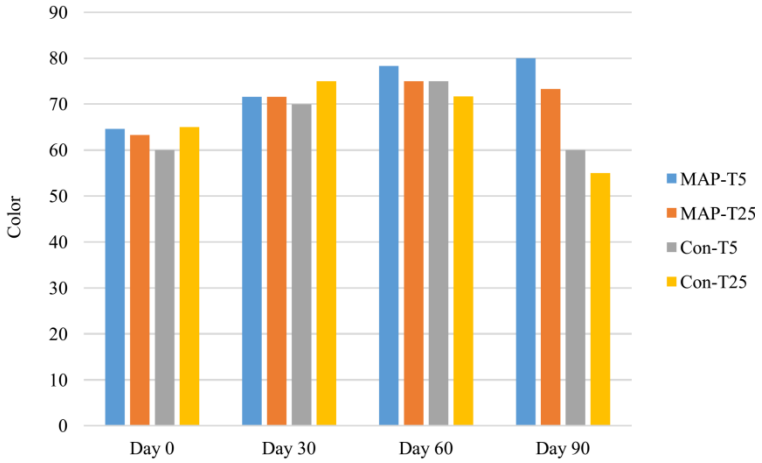


Figure 2: Mean color scores of date samples according to the 100-point hedonic scale analysis in control and modified atmosphere packaging groups (MAP-T5: modified atmosphere packaging group stored at 5 ℃; MAP-T25: modified atmosphere packaging group stored at 25 ℃; Con-T5: control group with usual packaging stored at 5 ℃; Con-T25: control group with usual packaging stored at 25 ℃)

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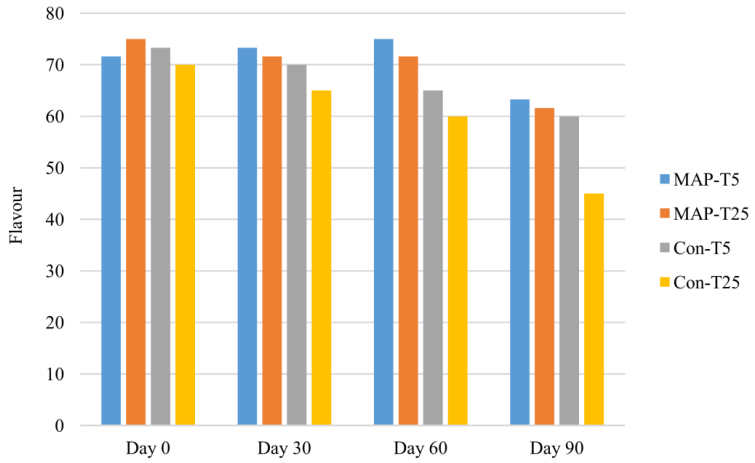


Figure 3: Mean flavor scores of date samples according to the 100-point hedonic scale analysis in control and modified atmosphere packaging groups (MAP-T5: modified atmosphere packaging group stored at 5 °C; MAP-T25: modified atmosphere packaging group stored at 25 °C; Con-T5: control group with usual packaging stored at 5 °C; Con-T25: control group with usual packaging stored at 25 °C)

Discussion

MAP is one of the suitable ways to reduce food wastes using convenient packaging and keeping the optimal conditions. The results of this research demonstrated that low temperature had a synergistic effect on the MAP. Succinic acid, isobutyric acid, citric acid, oxalic acid, and formic acid have been identified in dates (Hamad et al., 2015). Morgan and Benkeblia (2017) reported no significant difference between the pH of the ackee fruit arils stored in the osmolux and oriented polypropylene package at 10 °C. However, pH of the macro-perforate package increased from 5.32 to 5.98 and 5.83 at 5 °C and 10 °C, respectively. The pH reduction may be due to the permeability of CO_2 and also production of organic acid during fermentation of the product. In the same line with our findings, Azene et al. (2014) stated that after two days of storing papaya at the ambient temperature, the titratable acidity initially was decreased, but was followed by an increasing trend. At high temperatures and in presence of the favorable relative moisture in the environment, yeasts and molds turn the sugar content of dates into acid, contributing to increased acidity of dates. The amount and type of acids found in fruits compared with the soluble solids of juice affect the taste quality and post-harvest life of the fruits. The increase of acidity found in date samples of the present study may be due to the influence of the intra-cytoplasm through vacuoles or synthesis of organic acids.

One of the important qualitative characteristics in determining the flavor of fruits is the total number of the soluble solids shown in the form Brix degree (Wills and Golding, 2016). We found that MAP reduced the Brix degree and use of low temperature intensifies this effect. Our result is compatible with observations of two previous published reports (Alique et al., 2003; Tian et al., 2004) which demonstrated the effect of MAP on titratable acidity and total soluble solids of sweet cherry samples. Al-Redhaiman (2005) revealed that soluble solid content in dates was not affected by 20% CO_2, because this factor is slightly influenced by the process of ripening. However, after several weeks of storage, the amount of soluble solid content increased gradually through converting insoluble into soluble compounds. In the present work, increasing of Brix was observed over time, which could be related to cell wall alteration and break down of complex carbohydrates into simple ones occurring during the storage time (Kittur et al., 2001).

Dates, like the other agricultural products, may get microbial contamination in the farm and during transportation. Microbial spoilage can be controlled by drying dates up to 20% and storing them at the recommended temperatures and moisture during the process of transportation (Kader and Hussein, 2009). In most stages, including ripening on tree, storing, and processing, molds are the most important cause of date decay (Wills and

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Golding, 2016). Hasnaoui et al. (2010) found that the mean total bacterial count in date samples grown in Figuig Oasis of Morocco was reported as 1×10^2 Colony Forming Unit (CFU)/g, which was lower than that of date samples the present study. However, we found that MAP decreased the bacterial and fungal growth. These findings are consistent with an *in vitro* study carried out by Hoogerwerf et al. (2002) who showed the potential application of MAP with higher oxygen concentrations in order to reduction of some food-associated mould, including *Rhizopus stolonifer*, *Botrytis cinerea*, and *Penicillium discolor*. These researchers found that decreased mycelia growth was due to the reduced intracellular pH. Generally, the accumulation of CO_2 in the MAP inhibits the growth of aerobic bacteria and the difference in the microbial growth may be due to higher respiration rates at higher temperatures (Morgan and Benkeblia, 2017).

Tissue hardness, as one of the most important qualitative factors of many fruits, is under the effect of fruits pectin structure and texture freshness. Using MAP at 5 °C, the hardness of date samples was retained significantly. Based on the results of this study, the best hardness was related to samples packed under MAP at 5 °C and the largest tissue changes belonged to control samples kept at 25 °C. Low amount of oxygen reduces the ratio of respiration and chlorophyll degradation, and delays fruit ripening (Liamnimitr et al., 2018). Furthermore, presence of the fungi can stimulate the synthesis of ethylene and initiate the process of ripening through the enzymes involved in the decomposition of pectin and starch molecules (de Almeida Teixeira et al., 2018). On the other hand, the low temperatures can prevent the activity of pectin degrading enzymes. Since activity of degrading enzymes such as pectinesterase and also polygalacturonase is one of the most important factors in softening the fruits, any factor that causes delay in the activity of these enzymes can maintain the tissue firmness better (Imsabai et al., 2002; Wills and Golding, 2016). Also, we found that control dates without MAP had the lowest wettability at 25 °C. Similar results were reported in the previous researches carried out about effect of MAP on pomegranate (Candir et al., 2018) and Tunisian Deglet Nour date (Achour et al., 2003).

In all storage days, the MAP date group stored at 5 °C had the highest scores flavor and color; inversely, the lowest sensorial scores was related to control date samples stored at 25 °C. However, undesirable reactions were expected with increasing the days of storage and temperature; because continuation of ripening reactions, such as enzymatic reactions resulting from invertase, cellulase, and polygalacturonase, may decrease the flavor of fruits. Also, enzyme activity of invertase, polygalacturonase, and cellulase can change the color of fruits from brown to black (Kader and Hussein, 2009; Wills and Golding, 2016).

Conclusion

The results of this study showed that application of the MAP method along with low temperature increases the shelf-life of Iranian Mazafati dates.

Author contributions

H.S and J.S.Y contributed equally in designing and conducting the study, analyzing the data, and writing the manuscript. Both authors read and approved the final manuscript.

Conflicts of interest

Both authors declared that there is no conflict of interest.

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