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Effect of Modified Atmosphere Packaging (MAP) and Storage Temperature on Colour, Flavour, and Aroma of Saffron

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Abstract : The effect of different Modified Atmosphere Packaging (MAP) and storage temperature was investigated on the chemical compounds of saffron under different combination of Co_2 and N_2 include 100% N_2 (MAP1), 40% N_2 + 60% Co_2 (MAP2), and 60% N_2 + 40% Co_2 (MAP3) and different temperatures including 4°C, 25°C, and 35 °C for storing of samples for 12 weeks. Colour, flavour, and aroma of saffron were evaluated every three weeks. The results revealed colour and flavour of samples preserved under MAP1 were the most stable compared to MAP2 and MAP3 and 4 °C was the most efficient storage temperature.

Keywords: Aroma, Colour, Flavour, Modified Atmosphere Packaging (MAP), Saffron.

I. Introduction

Saffron spice is the dried red stigmas of saffron flowers (Crocus Sativus, L). It is most expensive spice and famous for its three unique sensory properties including of colour, flavour, and odour traditionally used for its colouring and flavouring abilities in food (Melnyk, Wang, & Marcone, 2010; Ordoudi & Tsimidou, 2004). The main agents of saffron properties are included crocin (a glycoside from the carotenoid crocetin) responsible for saffron strong colour (Ordoudi & Tsimidou, 2004); safranal (terpenic aldehydes) responsible for saffron aroma that compromise about 60% of volatile compounds in saffron (Abdullaev & Espinosa-Aguirre, 2004); and Picrocrocin (a glycoside terpenoid) responsible for saffron' s bitter taste (Carmona et al., 2006). These three compounds are major compound that determine high quality of saffron (Himeno & Sano, 1987). Saffron flowers traditionally harvested by hands through cutting and picking whole blue-purple flowers up early at the morning before heat and light of sunshine damage colour of saffron as well as quality (Melnyk et al., 2010). There are some methods for increasing quality of saffron and decreasing damages to its quality such as using mechanical methods in harvesting, conveying, separating, and drying stigmas (Antonelli, Auriti, Zobel, & Raparelli, 2011; Asimopoulos, Parisses, Smyrnaios, & Germanidis, 2013). One of the factor which can influence the quality of saffron over the storage period is packaging. Modified Atmosphere Packaging (MAP) is one of advanced technologies for controlling product deterioration by providing an appropriate and modified atmosphere of Co_2 and O_2 levels around the fresh fruits and vegetables sealed in the polymeric film leading to maintenance of the natural quality(Mir & Beaudry, 2004). It has provided presenting products with increased shelf-life and higher quality (Sivertsvik, Rosnes, & Bergslien, 2002) and proved to be most significant and effective method for extending shelf-life of products by decreasing O_2 levels and increasing Co_2/N_2 levels at chill temperature (Parry, 2012). MAP along the low storage temperature has been reported to be most effective in extending shelf-life of harvested crops and its using for Fenugreek has shown a better maintenance of colour pigment (Chlorophyll) as well as its (Church & Parsons, 1995). However, Modified Atmosphere Packaging has shown benefits in increasing shelf-life of harvested-crops, its effect on saffron stigmas has not studied so far. Therefore, this research aimed to investigate the effect of Modified Atmosphere Packaging (MAP), storage temperature, and time storage on the three chemical compounds of saffron include crocin, picrocrocin, and safranal over the storage.

II. Materials and Methods

Materials

The Negin Pushal saffron (common name in Iran) or Mancha saffron (its name in international markets) was obtained from a Local saffron supplier of Torbat Heydarieh city in saffron season in autumn. The flexible three layer-layered plastic bag (PE/PA/PE), 70 µ thick was used for packaging of saffron samples. The MAP machine (HENKELMAN 200A, made in Netherland) was connected to the mixing cylinder of the gas supply system, and the air was removed by a vacuum pump.

Storage conditions and preparation of the samples

Based on our statistical method, saffron stigmas were weighed, packed under MAP condition and divided. As the O_2 has negative impacts on saffron quality (Oxidation of colour pigment), our gas combination was determined as N_2 and Co_2 in following percentage for MAP treatments: MAP1 (100% N_2), MAP2 (60% N_2 + 40 % Co_2), MAP3 (40% N_2 + 60 % Co_2) and removing O_2 from the packages. Time treatments include 0, 3^{rd}, 6^{th}, 9^{th} and 12^{th} weeks. Samples were kept at 4 °C in refrigeration and 25 °C and 35 °C inside the incubators.

Statistical analysis

Analysis of variance (ANOVA) and SPSS System (version 9.0 software) were conducted to investigate the effects of gas combinations and storage temperatures. To determine the statistical differences, mean comparisons between features were performed using Duncan tests at a significant level of $P < 0.05$.

Chemical test

The below method was used to measure the saffron crocin, picrocrocin, and safranal. A reflectance spectrophotometer (SHIMADZU uv-160A, made in Japan) measured colour, flavour, and aroma according to ISO/TS 3632. The changes in the absorption spectra were evaluated at the following wavelengths:

A (257 nm) absorbance (λ max Picrocrocin),
A (330 nm) absorbance (λ max Safranal)
A (440 nm) absorbance (λ max Crocin)

$$A^{\%1}_{1cm} (\lambda \max) = \frac{D \times 1000}{m \times (100 - w)} \quad (1)$$

In this formula, D, m and w are respectively the absorption of all items listed, mass of the sample (in grams) and amount of moisture. For determining of the mass moisture content, the following procedure described by equation (2) was used based on ISO/TS 3632. This method is based on measuring the difference in the weight of samples before and after drying in the oven at 102±3°C for 16 h. Moisture data were obtained from the formula.

$$w = (m0 - m)\ 100/m0\%$$

Formula 2 - moisture measurement in saffron

m0: Mass in grams of test portion m: Mass in grams of dry residue w: Moisture content (percent per gram)

The study was also conducted by using randomized design in a factorial. Samples were analysed in triplicate. Statistical data using SPSS and Excel 2011 software was used to draw graphs.

III. Result and tables

Effect of MAP, temperature, and time on the amount of Crocin

According to Figure. 1., MAP, temperature, and storage time had significant impact on the amount of crocin ($p<0.05$). In Figure. 1. A, the amount of crocin in MAP1 had the highest value compared to MAP2 and MAP3 after 12 weeks and was closest to the control sample. Increasing temperature from 4°C to 35°C, resulted in reducing colouring ability but the decline was much less at 4°C (Figure. 1. B). Alonso et al also has reported the same result that increasing in temperature causes spontaneous oxidation and decomposition crocin to picrocrocin (Alonso, Varón, Salinas, & Navarro, 1993). Time also had a significant impact on the amount of crocin (Figure. 1. C).

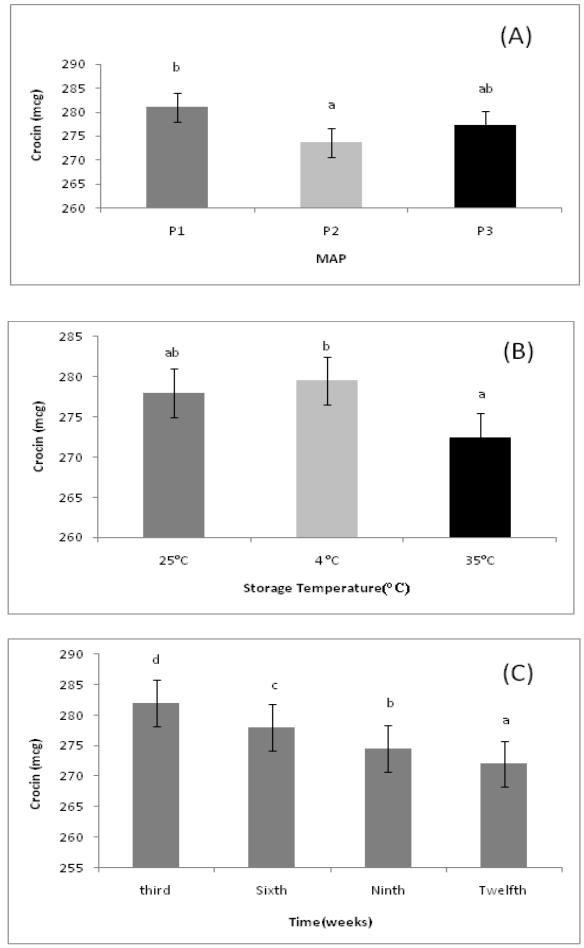

Fig. 1 Effect of MAP (A), Storage Temperature (B), and storage time (C) on Crocin amount of saffron .Different superscripts indicate significant differences at $P< 0.05$ and error bar represent standard deviation.

According to Figure. 2, by increasing temperature crocin changes into Crocetin and the maximum and minimum reduction in crocin was observed at 35°C and 4°C. The previous reserch has reported that during storage, Glycozyl esters of crocin breakdown and its value decrease (Morimoto et al., 1994).

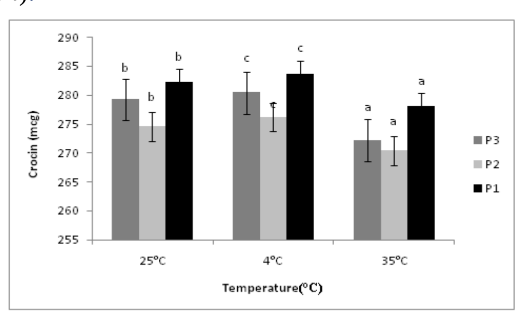

Fig. 2 Effects of MAP and storage temperature on Crocin amount of saffron. Different superscripts indicate significant

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differences at $P< 0.05$ and error bar represent standard deviation

Effect of MAP, temperature and time on the amount of picrocrocin

The results of our experiments demonstrated that MAP, temperature, and storage time had a significant effect on picrocrocin amount ($p<0.05$). Based on Figure. 3. A, the highest and lowest amount of picrocrocin were observed in MAP1 and MAP3. Among three temperatures, the maximum and minimum reduction was at 35°C and 4°C, respectively (Figure. 3. B). By increasing storage time, picrocrocin was reduced (Figure.3 .C).

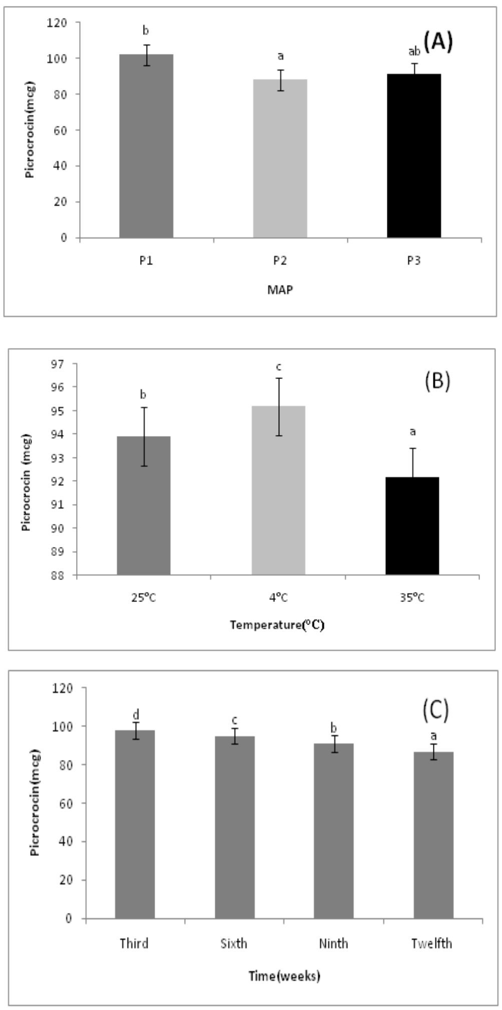

Fig. 3 Effect of MAP (A), storage temperature (B), and storage time (C) on Picrocrocin amount of saffron. Different superscripts indicate significant differences at $P< 0.05$ and error bar represent standard deviation.

Based on figure. 4, MAP1 and 4°C had the lowest reduction in picrocrocin and were closest to first season saffron.

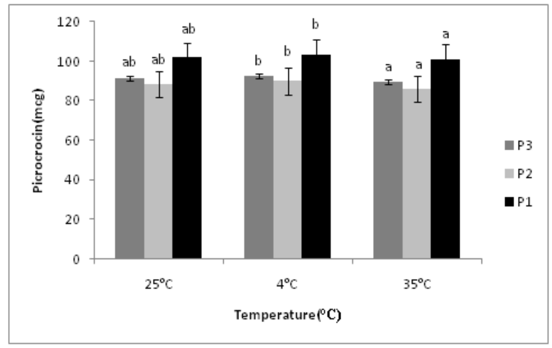

Fig. 4 Effect of temperature and MAP on picrocrocin amount of saffron. Different superscripts indicate significant differences at $P<0.05$ and error bar represent standard deviation.

Effect of MAP, temperature, and time on the amount of safranal

Results showed that MAP, temperature, and storage time had a significant effect on amount of saffranal ($p<0.05$). The maximum and minimum of safranal were found in MAP2 and MAP1, respectively. By increasing temperature, saffranal amount increased and maximum and minimum changes were observed at 35°C and 4°C, respectively (Figure. 5. B). In the terms of storage time, amount of safranal elevated by passing time (Figure. 5. C).

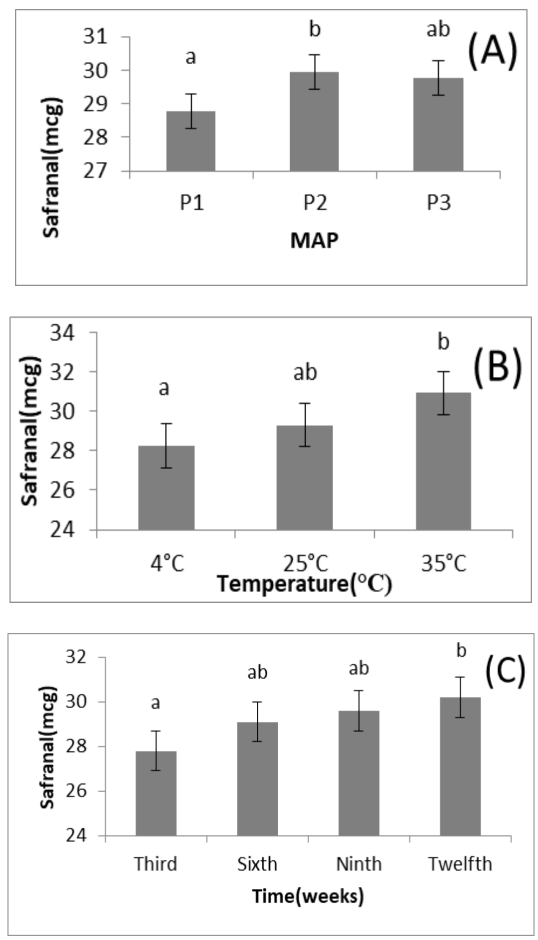

Fig. 5 Effect of MAP (A), Storage temperature (B), and Storage time (C) on safranal amount of saffron. Different superscripts indicate significant differences at *P*< 0.05 and error bar represent standard deviation.

Figure 6 shows the interaction between temperature and MAP on safranal during storage time. As the amount crocin and picrocrocin decrease, the amount of safranal increases and the highest level was seen in MAP2 and 35°C.

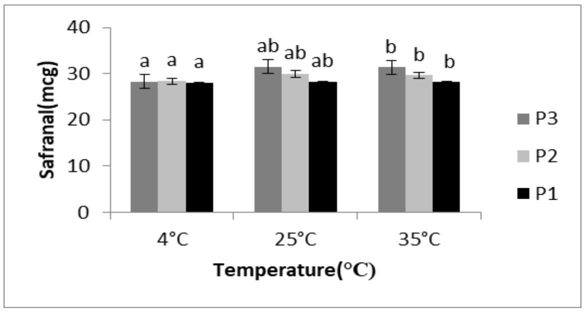

Fig. 6 Effect of MAP and storage temperature on the safranal amount of saffron. Different superscripts indicate significant differences at *P*< 0.05 and error bar represent standard deviation.

IV. CONCLUSION

The results show by increasing temperature and time, the amount of crocin and picrocrosin decrease. This decline in MAP1 was much slower and slighter than the others two caused the results came closer to control samples. Thus, the best MAP and temperature for keeping first season saffron are MAP1 and 4°C.

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