Effect of Modified Atmosphere Packaging (MAP) on the Moisture and Sensory Property of Saffron

Abstract
In this research, the effect of different Modified Atmosphere Packaging (MAP) and storage temperature was investigated on the moisture and sensorial properties of saffron under different conditions. Saffron samples were packed by using different combinations of CO₂ and N₂ including: MAP1 (100% N₂), MAP2 (40% N₂ + 60% CO₂) and MAP3 (60% N₂ + 40% CO₂) and were stored at three different temperatures (4°C, 25°C and 35°C) for 12 weeks. Moisture and sensorial properties of samples were evaluated every three weeks. The results revealed that the moisture of saffron samples were preserved more favourably with MAP1 than with MAP2 and MAP3. Regarding temperature, 4°C was the most efficient. Results of sensory evaluation indicated that MAP1 had a significant positive effect on the external appearance of saffron samples.

Keywords: Modified Atmosphere Packaging (MAP); Moisture; Saffron; Sensory evaluation; Temperature

Abbreviations: MAP: Modified Atmosphere Packaging

Introduction
Saffron is the most precious natural spice in the world derived from Crocus sativus L. flowers. It has unique sensorial properties including colour, flavour, and odour. Modified Atmosphere Packaging (MAP) is one of advanced technologies for controlling product deterioration by providing an appropriate protective atmosphere around the product [1]. The aim of MAP is to exhaust the air inside the packaging and create vacuum, or replace the air with a mixture of gases which can control the chemical, enzymatic and microbial activities of the food. MAP is one of the most important food preservation methods that maintains the natural quality and extends the storage life of fruits and vegetables [2,3]. Packaging of fenugreek in two perforation packets with mustard seeds resulted in the best maintenance of chlorophyll, ascorbic acid, phenols and aroma [4]. It has also proved to be one of the most significant and innovative growth areas in retail and food packaging of the past two decades [5]. The accumulation of CO₂ and O₂ in a beneficial level by the application of MAP is known to extend the post-harvest life of many horticultural products [6,7]. MAP can be achieved by use of polymeric films where gas transmission across the film and the levels of CO₂ and O₂ within the package can be controlled [8]. Storage temperature influences the rate of many deteriorative processes and transcription because the temperature is one of the most important factors in the maintenance of product quality [9]. The aim of this research was to evaluate the effect of MAP, storage temperature and time on the moisture and sensory properties of first-season saffron.

Materials and Methods

Materials
The Negin Pushal saffron (common name in Iran) or Mancha (common name in international markets) was obtained from a Local supplier in Torbat Heydarieh (a city in khorasan Razavi province) during saffron season. The film used as package was a flexible 3 layers-layered plastic bag (PE/PA/PE), 70 µm thick. 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. Oven (SHELDON, made in U.S.A) controlled the temperature at 102 ± 3°C for saffron drying.

Storage conditions and preparation of the samples
The samples were weighed, packed and divided according to statistical analysis. Due to the negative effect of O₂ on saffron (oxidation of colour pigment) our gas combination in this research included N₂ and CO₂ in following percentages for MAP treatments: MAP1 (100% N₂), MAP2 (60% N₂ + 40 % CO₂), MAP3 (40% N₂ + 60 % CO₂). Time treatments for sampling were 0, 3th, 6th, 9th and 12th weeks. Samples were also kept at 4°C in refrigeration and 25°C and 35°C inside the incubators.

Sensory tests
The external visual characteristics of saffron were determined over the storage time by 20 trained panel members informed of the sensory attributes. The observed characteristics were colour changes (bright red up to dark red), the presence of...
off-odours (from no off-odours up to appreciable off-odours),
flavour changes and total acceptance. A five-point Hedonic scale
evaluation including: 1, very bad; 2, bad; 3, middle; 4; good 5, very
good was used where, 5 corresponding to a most-liked sample
and 0 corresponding to a least-liked sample.

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 \( P < 0.05 \).

Result and Discussion

Chemical test

For determining mass moisture content of saffron, the following
procedure described by equation (1) was used according to ISO
3632. This method was 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.

\[
W = \frac{(m_0 - m)}{m_0} \times 100 \%
\]

Formula 1- moisture measurement in Saffron

\( m_0 \): Mass in grams of test portion
\( m \): Mass in grams of dry residue
\( w \): Moisture content (percent per gram)

Analysis and the results of study

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

Effect of MAP, temperature and time on the moisture:

Results of moisture measurement are shown in Figure 1. Analysis of data
showed that MAP, storage temperature and time have a significant
impact on the moisture of saffron \( (p < 0.05) \). The amount of
moisture in MAP1 had the highest value compared to MAP2 and
MAP3 after 12 weeks of storage, and it was closest to the control
samples (Figure 1A). MAP1 (100% \( N_2 \)) had the best effect on the
moisture and freshness of saffron.

Increasing the temperature from 4°C to 35°C resulted in reduced moisture in the saffron
samples, but the decline is much less at 4°C and samples were
closest to our control samples (Figure 1B). The use of low storage
temperature (refrigerator temperature) is best to preserve
moisture in saffron. Amount of moisture declined over time, but
the reduction was slighter and slower in MAP1 (100% \( N_2 \)) (Figure
1C). Therefore, a combination of MAP, with \( N_2 \) and temperature
(4°C) is suggested for packaging and keeping saffron to maintain
its moisture for long time. Debevere et al. [10] reported that the
most important and efficient technology used to maintain the
quality of fish products [10].

Sensory evaluation

The sensory evaluation of saffron samples during the storage
time are shown on Figure 2. In terms of colour, samples showed
change differences with different MAPs. A brilliant red colour
similar to the control samples was observed with MAP1 (100 %
\( N_2 \)). Saffron with MAP2 (40% \( N_2 \) + 60% \( CO_2 \) ) also had dark brown
colour and there was a combination of dark red to brown colour
with MAP3 (60% \( N_2 \) + 40% \( CO_2 \) ) (Figure 2A). Thus, it is confirmed
that the quality of external saffron colour steadily increased over
time with MAP1 (100% \( N_2 \)). Regarding flavour, MAP1 (100% \( N_2 \))
showed the best flavour and came closest to the control samples.
The lowest intensity of flavour was obtained with MAP2 (Figure
2B). The highest intensity of aroma was also obtained with
MAP2 (Figure 2C). The total acceptance of saffron samples with
MAP1 and MAP2 corresponded to the highest and lowest ranks,
respectively (Figure 2D). Saffron color was the most important
factor regarding the interest of consumers.

Conclusion

The results of analyses show that as temperature and time
increased, the amount of moisture and consequently, the

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appearance and freshness of saffron decreased. Declines of moisture and external sensory evaluation of saffron samples packaged under MAP1 (100% N₂) was much slower and slighter than with the two other packaging procedures, and the results obtained came closer to the control sample. It is concluded that the best kind of MAP packaging and temperature for keeping the first season saffron quality were MAP1 (100% N₂) and 4°C. Based on the results of sensory acceptability, the highest and lowest ranks were assigned to MAP1 and MAP2 respectively. In summary, the results indicate that N₂ in three-layer films maintained a higher level of saffron quality. The temperature of 4°C also created a favourable condition for moisture and sensory quality of saffron.

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Conflicts of Interest

None of the conflicts.

References