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Cold storage of oil rose (*Rosa damascena* Mill.) flowers

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ABSTRACT

Oil rose flowers were stored at 0 °C in four different packaging materials [plastic box + stretch film (PB + SF), Xtend®, Smartbag® and polyethylene (PE)] for 60 days. During storage, weight loss, O_2 and CO_2 concentrations in the packages, petal color and sensorial attributes were investigated besides essential oil content and composition. Storage duration and packages had significant ($p < 0.01$) effects on weight loss. At the end of storage, the lowest weight loss was in PE package (1.696%) whereas the highest weight loss was in Xtend® (10.081%). The essential oil content was significantly ($p < 0.01$) affected by storage duration and packages. In addition, the essential oil contents obtained from all packages for a storage period of 10 days and the essential oil contents obtained from unstored (control) petals were included in the same group. At the end of storage, the essential oil contents decreased by 91.3, 57.7, 80.0 and 64.3% in PB + SF, Xtend®, Smartbag® and PE packages, respectively as compared to control. In addition, storage duration and package types significantly ($p < 0.01$) affected petal color, O_2 and CO_2 concentrations in the packages and sensorial scores. The concentration of citronellol, a main component of rose oil, increased in all packages during storage of 10 days in comparison to the control group while it varied in other storage durations and package types. However, nerol and geraniol were lower than the control group during storage while concentrations of nonadecane, heneicosane and eicosane were higher. In conclusion, loss of oil yield and quality, due to various reasons and particularly due to fermentation in oil rose from the harvest of petals to their distillation, can be minimized with storage of petals in all package types for up to 10 days.

1. Introduction

Damask rose (*Rosa damascena* Mill.) is the most important rose species used in essential oil production in the world (Tucker and Maciarello, 1988). Damask rose is primarily cultivated in Turkey, Bulgaria, Morocco, Iran, India, South Russia, South France, China, South Italy, Libya and the Ukraine in the world (Staikov and Kalaijiev, 1980; Weiss, 1997; Büttner, 2001). The most important production centers today are Turkey (Isparta) and Bulgaria (Kazanlik). The main products of Damask rose are rose oil, rose water, rose concrete, rose absolute and dried petals and these products are used in perfume, cosmetic, pharmaceutical and food industries (Kürkçüoglu and Başer, 2003; Göktürk Baydar et al., 2004).

Oil rose flowers annually once and its flowering period lasts for about 35–45 days (from the second half of May to the end of June) in Turkey. The rose flowers, handpicked daily at the early morning (05:00–10:00) of the day throughout the flowering period, are delivered to rose oil factories for distillation. Some of the rose flowers delivered to factories are distilled immediately whereas a considerable amount of them are stored left in piles a long time (12–24 h) due to excessive amount of flowers. Nevertheless, in practice, only fresh rose petals are preferred for oil production. Fermentation starts in the flowers due to excessive temperature both while being transported to factories after harvest and while being waited at the factories until distillation. There are considerable losses of essential oil yield and quality in fermented petals (Kazaz and Kelen, 1999; Baydar and Göktürk Baydar, 2005). For instance, it was reported that the oil content in the petals distilled immediately after the harvest was 0.035% and that it became 0.030% 12 h later, 0.027% 24 h later and 0.025% 36 h later (Baydar and Göktürk Baydar, 2005).

The most important factor in maintaining postharvest quality of fruits and vegetables and extending shelf life is temperature (Tano et al., 2007). In general, as storage temperatures increase, losses of quality occur more rapidly (Ding et al., 1998; Jacxsens et al., 2002; Maalekuu et al., 2006). Thus, many products are stored at 0–5 °C both in order to maintain quality and to extend shelf life (Varoquaux and Wiley, 1994). In addition, respiration rate can be decreased and shelf life can be extended in many products by modifying the atmosphere surrounding the product (Burton, 1979). Also known as Modified Atmosphere Packaging (MAP), this system depends on the principle that the amount of oxygen decreases and the amount

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of carbon dioxide increases as a result of the respiration of products in special packages with different gas permeability. Besides, the humidity level of the atmosphere in the package is preserved and the duration of storage is extended (Kader, 2003; Thompson, 2003). Low temperature and modified atmosphere packages reduce loss of water, respiration rate and production of ethylene, prevent darkening and some physiological deteriorations and delay microbial development and decay (Varoquaux and Wiley, 1994).

With storage of oil rose flowers both at low temperatures and in modified atmosphere packages, both reductions in oil content and quality and deteriorations and decays of petals can be prevented. Numerous studies have been conducted on different storage conditions of fruits, vegetables and cut flowers. However, there has been no report on the effects of cold storage of oil rose flowers on oil content, oil composition and storability of oil rose flowers so far. Therefore, this study was carried out in order to determine the effects of storage (storage duration and different modified atmosphere packages) on the oil yield and quality of oil rose flowers and on some of their physical, chemical and sensorial attributes.

2. Materials and methods

2.1. Plant material

Oil rose (*R. damascena* Mill.) flowers were hand-harvested from a commercial oil rose garden, located in Isparta (Turkey), on June 16, 2008 at the early hours of the day and delivered to the laboratory within 20 min after the harvest.

2.2. Storage conditions

The rose petals delivered to the laboratory were divided into two groups. The petals used as control group (unstored) were immediately subjected to distillation whereas the other petals were reserved for cold storage experiments. For cold storage experiments, 4 different packaging materials that provided modified atmosphere were used: plastic box (PB)+ 12-μm-thick polyvinylchloride (PVC) stretch film (SF) (Rotopaş Ambalaj Ltd., İstanbul, Turkey), microperforated 20-μm-thick Xtend® (StePac L.A. Ltd., Tefen, Israel) packages, microperforated 20-μm-thick Smartbag® (Long Life Solutions Ltd., North Berwick, United Kingdom) packages and 7.21-μm-thick ordinary PE (Prim Ambalaj Ltd., Mersin, Turkey) packages. 0.5 kg of petals was placed in each package. Rose petals were stored in cold room at 0 °C and 90 ± 5% RH for 60 days. At the commencement of storage, the petals placed in modified atmosphere package (MAP) were weighed, their petal colors were measured and their sensory evaluations were made. Loss of weight, petal color, gas composition in the packages (CO_2 and O_2), sensorial attributes, essential oil content and essential oil components were analysed during storage at 10-day intervals on the petals that were removed from cold storage.

2.3. Weight loss

Weight loss was determined by weight measurement before and after storage. Weight loss was expressed as the percentage of loss of weight with respect to the initial weight.

2.4. Carbon dioxide (CO_2) and oxygen (O_2) concentrations

Gas concentration (O_2 and CO_2) in the packages was measured by Gaspace 2 (Gas Headspaceanalyser, Systech Instruments). The instrument is capable of reading between 0.001 and 100% oxygen. The analyser measures oxygen content using a high purity, high density stabilised zirconia ceramic. This is a proven and reliable measurement technique. The carbon dioxide analysis is accomplished by a patented infra-red technique which has no moving parts and gives a range of 0–100%. The analyser also calculates the balance gas and displays this on the front panel. This value is normally assumed to be nitrogen. The reference gas is air (20.9% oxygen, 0.3% carbon dioxide), suitable gases are all inert gases, ambient temperature is 0–40 °C, size is 420W × 160H × 360D (mm).

2.5. Petal color (L^*, a^* and b^*)

The color change in the petals was determined in terms of L* (brightness-darkness), a* (+a*: red, −a*: green) and b* (+b*: yellow, −b*: blue) by Minolta CR-300 (Minolta Ramsey, NJ, USA) color apparatus. Color measurements were performed at two points on both surfaces of 10 petals selected randomly in each replication and given as the mean value of both surfaces. Minolta color measurement apparatus was calibrated according to standard white plate (Y = 93.9, x = 0.313 and y = 0.321).

2.6. Sensory evaluation

A panel of 15 trained judges evaluated the sensory quality characteristics of all the flowers. Sensory evaluation (general appearance, odor) were performed on a scale of 1–9, where 1 represented very bad, 2 represented bad, 3 represented fair, 5 represented marketable, 7 represented good, 9 represented excellent and those scored with 5+ points were regarded as marketable.

2.7. The essential oil content

The essential oils of rose flowers were obtained in a Clevenger-type hydro-distillation apparatus. 500 g of rose petals were filled in a 4 L Clevenger apparatus and subjected to distillation for 3 h after 1.5 L of pure water had been added on it. The quantities of rose oils obtained at the end of distillation were measured as mL and % ratios (v/w) were determined.

2.8. The essential oil components

The components of the oil samples were analysed by gas chromatography–mass spectrometry (GC–MS). GC–MS analysis was performed on QP5050 GC–MS (Shimadzu, Japan) equipped with a Quadrapole detector. GC–MS analysis was carried out as follows: capillary column, CP-Wax (polyethylene glycol) 52 CB (50 m × 0.32 mm i.d., film thickness, 0.25 μm), oven temperature was kept at 60 °C for 10 min and programmed to 220 °C at a rate of 10 °C min^{-1}, and then kept constant at 220 °C for 10 min, total run time 60 min, injector temperature, 240 °C; detector (70 eV) temperature, 250 °C; flow rate for helium, 1.2 mL min^{-1}; split ratio, 1:5; injection volume, 1 μL. Identification of constituents was carried out with the help of retention times of standard substances by composition of mass spectra with the data given in the NIST library (Stein, 1990) and our created library.

2.9. Experimental design and statistical analyses

The experiment was set up according to Randomized Blocks experimental design with 3 replications and each package weighing 0.5 kg was regarded as a replication. Data were subjected to analysis of variance by a SAS (SAS Institute, 1998) package. Mean values were compared using the Duncan's multiple range test.

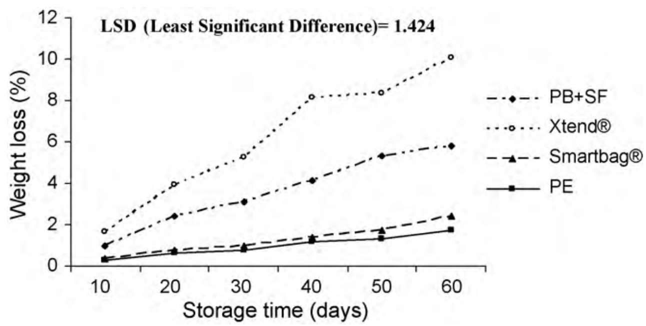

Fig. 1. Weight losses of rose petals cold stored in different modified atmosphere packages during storage (%).

3. Results

3.1. Weight loss

Weight loss of rose flowers was influenced significantly ($p < 0.01$) by different storage conditions (PB + SF, Xtend®, Smartbag® and PE) during storage. An increase was found in weight loss (%) of roses with increasing storage period. At the end of storage, the highest weight loss (10.081%) was observed in rose petals stored in Xtend® while the lowest weight loss (1.696%) was in PE packages, which were followed by Smartbag® and PB + SF packages (Fig. 1).

3.2. CO_2 and O_2 concentrations in the packages

At the end of storage, Xtend® was the package with the highest (15.375%) O_2 level in the package whereas PE was the package with the lowest (1.960%) values. PE was followed by Smartbag® and PB + SF packages. At the end of storage, the highest value (5.675%) in terms of CO_2 level in the package was found in PE while Xtend® was the package with the lowest (2.875%) CO_2 level. It was followed by Smartbag® and PB + SF packages (Fig. 2a and b). CO_2 and O_2 concentrations in the packages were influenced significantly ($p < 0.01$) by storage durations in all package types.

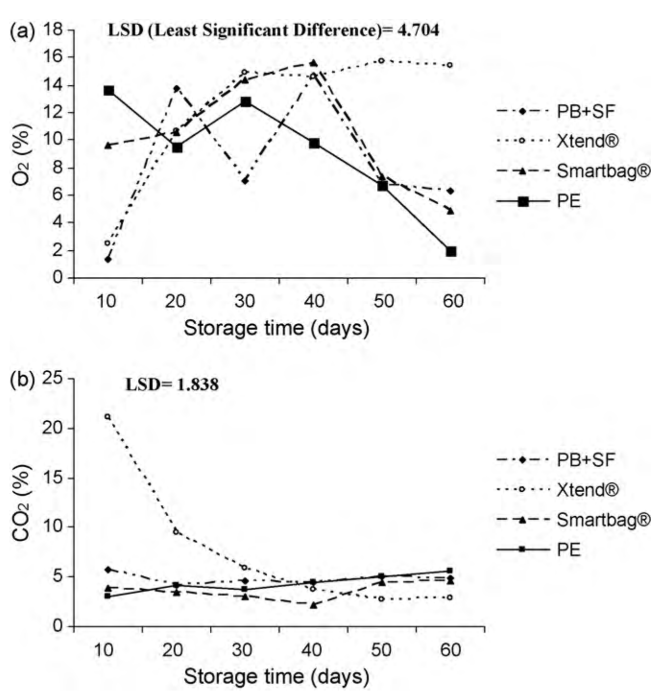

Fig. 2. (a) Changes of O_2 concentration in packages during cold storage period (%). (b) Changes of CO_2 concentration in packages during cold storage period (%).

3.3. Petal color

The effects of different storage conditions (PB + SF, Xtend®, Smartbag® and PE) on L*, a* and b* values of rose petals were statistically significant ($p < 0.01$) during storage. Even though the L* value of petal color varied during storage, there was an increase, although slightly, in brightness (an increase in L* value) at the end of storage in comparison to the initial value. At the end of storage, the flowers in Smartbag® had brighter petals than other applications whereas the petals in PE were slightly duller than the others. Xtend® was the package where the petal color underwent the highest change and lost its pink color (a decrease in a* value and an increase in b* value) and the rose petals stored in PB + SF preserved their colors better than other packages (Fig. 3a–c).

3.4. Sensory evaluation

The variations in the sensorial scores of rose petals are presented in Fig. 4. There were statistically significant differences ($p < 0.01$) between storage duration and packages in terms of sensorial attributes. At the end of storage, those scored with 5+ were

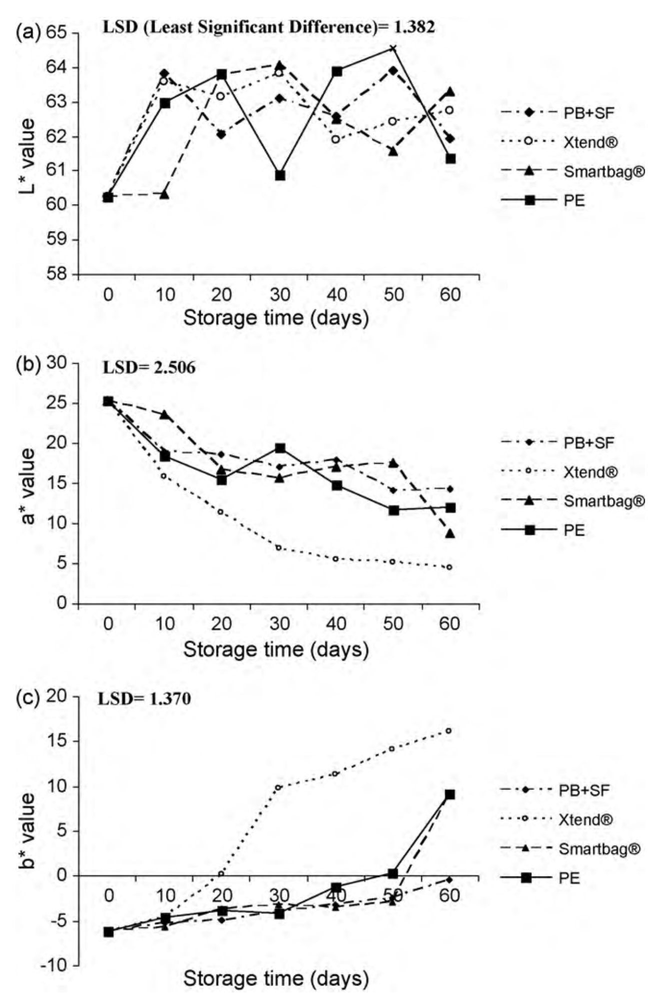

Fig. 3. (a) L* (brightness-darkness) color values of rose petals cold stored in different modified atmosphere packages. (b) a* (+a*: red, −a*: green) color values of rose petals cold stored in different modified atmosphere packages. (c) b* (+b*: yellow, −b*: blue) color values of rose petals cold stored in different modified atmosphere packages.

Table 1
Effects of storage period and package types on oil composition of rose petals.

Period (days)	Package	Hexadecane	Citronellol (C)	Nerol	Geraniol (G)	Nonadecane	9-Nonadecane	Eicosane	Methyl eugenol	Heneicosane	Eugenol	Linalool
	Control (0)	0.47	39.32	9.59	23.61	12.20	0.55	0.67	0.97	8.33	0.55	0.52
10	PB + SF	1.97	41.03	0.57	1.90	27.77	3.67	2.29	1.31	16.21	0.14	0.45
	Xtend®	1.73	47.43	2.26	4.88	35.77	2.72	3.58	1.60	26.44	1.09	–
	Smartbag®	2.44	42.00	0.69	2.55	25.20	3.63	1.57	1.43	13.80	0.13	0.78
	PE	1.26	47.53	1.20	5.63	24.48	3.37	0.87	0.79	11.80	0.24	–
20	PB + SF	1.72	15.53	0.20	1.71	42.44	3.50	4.05	1.35	30.14	0.33	0.30
	Xtend®	1.99	16.73	–	1.36	43.70	3.93	3.87	1.23	28.15	0.13	0.20
	Smartbag®	1.28	21.18	–	0.54	44.68	2.21	4.10	0.50	35.84	0.26	–
	PE	2.92	37.05	0.20	1.45	29.28	4.55	1.88	2.40	13.20	0.20	0.75
30	PB + SF	3.12	8.18	0.20	1.04	45.04	2.49	4.64	1.18	34.69	0.38	0.65
	Xtend®	2.30	37.89	0.44	1.35	29.58	2.18	2.49	1.51	19.44	0.10	0.40
	Smartbag®	2.72	2.71	–	–	50.50	3.34	5.06	0.16	35.50	0.41	–
	PE	0.91	4.13	–	–	48.62	1.73	4.16	–	38.20	–	–
40	PB + SF	3.42	7.24	–	0.95	46.70	3.31	4.32	–	32.41	–	–
	Xtend®	1.90	34.57	0.20	1.36	43.47	3.41	3.76	2.01	26.75	0.11	0.51
	Smartbag®	3.78	17.00	0.23	1.65	45.33	4.49	4.06	1.37	26.32	0.13	–
	PE	1.00	–	–	–	51.12	2.35	5.45	–	38.61	–	–
50	PB + SF	2.37	35.68	–	0.59	33.16	2.85	2.24	0.98	18.89	0.10	0.49
	Xtend®	2.31	44.28	0.48	1.94	27.20	2.51	2.13	1.51	13.70	0.10	0.49
	Smartbag®	2.24	–	–	–	54.15	2.03	4.83	–	37.83	–	–
	PE	3.14	4.48	0.18	0.50	49.14	3.65	4.71	–	32.75	0.37	1.21
60	PB + SF	–	–	1.70	–	41.75	0.33	5.41	–	51.52	–	–
	Xtend®	2.01	47.51	0.29	1.66	27.15	1.72	2.19	1.16	15.06	0.41	–
	Smartbag®	0.61	1.31	–	–	50.91	1.58	5.39	–	38.87	–	–
	PE	1.29	1.45	–	–	47.41	0.79	5.48	–	42.96	–	–

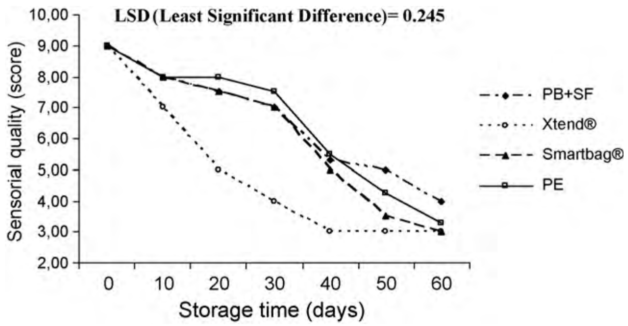

Fig. 4. The effects of storage duration and package types on sensorial quality of rose petals (score).

evaluated as acceptable. The sensorial scores granted for all package types decreased with increasing storage duration. In a storage period of 30 days, all packages except for Xtend® were found to be above the acceptable limit of 5.0. While a severe decrease was observed in the scores after a storage period of 40 days, the scores of all packages were found to be under the acceptable limit of 5.0 at the end of storage. At the end of storage, the best sensorial score was presented by PB + SF and it was followed by PE group. However, the worst sensorial scores were in the petals stored in Xtend® and Smartbag®. It was determined that Xtend® was the package that preserved the characteristic rose odor best in comparison to other packages although it did not display very good attributes in terms of color.

3.5. Essential oil content

No significant difference was observed between the oil contents obtained from unstored petals and the oil contents obtained from the petals in all package types at the end of a storage period of 10 days. Oil content decreased significantly ($p < 0.01$) in all package types during the storage period of 20 days and during the following storage periods in comparison to the commencement of storage. During the storage period of 60 days, the highest rate of essential oil loss was in PB + SF (91.3%) while the lowest rate of essential oil loss was in Xtend® (57.7%) (Fig. 5).

3.6. Essential oil composition

Effects of storage durations and package types on oil composition are given in Table 1. Concentrations of citronellol, nerol and geraniol are the main components of oil, which 39.32, 9.59 and 23.61% in the petals in the control group, respectively. It was determined that the concentration of citronellol was higher in all package types at the end of a storage duration of 10 days than the control group whereas it had lower values during other storage durations apart from Xtend® package in the storage periods of 50 and 60 days. On the other hand, concentrations of nerol and geraniol had lower values than the control group during all storage periods. It was determined that the concentrations of nonadecane, eicosane and heneicosane in the petals of the control group were 12.20, 0.67 and 8.33%, respectively. However, in the stored petals, each of three components had higher values than the control group in all package types. It was determined that citronellol/geraniol (C/G) ratio, an important criterion in determining the quality of rose oil, was 1.67 in the control group. In a storage period of 10 days, the lowest C/G ratio was obtained from PE (8.44) while the highest ratio was obtained from PB + SF (21.67). In the storage period of 20 days, the lowest C/G ratio was obtained from PB + SF at the rate of 9.08 while the highest ratio was obtained from Smartbag® at the rate of 39.22. It was determined that C/G ratio ranged from 7.62 to 60.47 during the storage periods of 30, 40, 50 and 60 days (data were not given).

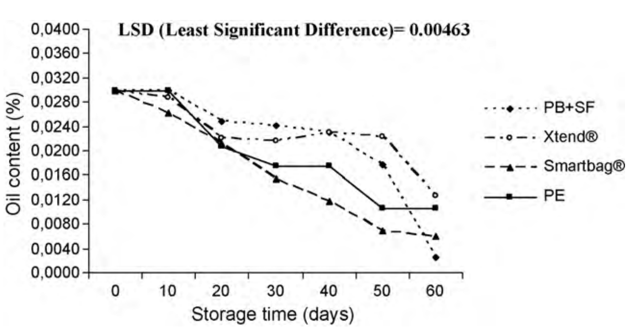

Fig. 5. Effects of storage period and package types on essential oil content of rose petals.

4. Discussion

4.1. Weight loss

One of the most serious problems encountered during the storage is the weight losses during storage. In the study, the weight losses generally increased in all MAP types as storage duration extended. At the end of storage, the highest weight loss was in Xtend® package (10.081%) while the lowest weight loss was in PE package (1.696%). The water vapor permeability of packaging materials might influence weight loss of rose flowers during storage. Considering the low weight loss in PE packages, it may be concluded that the water vapor permeability of this package type is lower than those of other packages. On the other hand, the water vapor permeability of Xtend® package, where the highest weight loss is observed, is higher than other packages. Similar results have been reported by Yaman and Bayındırlı (2002).

4.2. O_2 and CO_2 concentrations in the packages

In the study, it was found that O_2 and CO_2 levels in the packages varied depending on storage duration and package type. At the end of storage, O_2 levels in the packages were higher whereas CO_2 levels were lower in Xtend® and PB + SF than the others and O_2 levels were lower while CO_2 levels were higher in PE and Smartbag® packages than the others. The obtained results are partially similar to the findings by Tano et al. (2007), who reported that O_2 concentration decreased and CO_2 concentration increased in different products with storage in modified atmosphere packages. The variations among the results may be due to product type, package type and permeability as well as storage conditions and duration. With the highest O_2 (15.375%) concentration and the lowest CO_2 (2.875%) concentration at the end of storage, Xtend® package showed higher permeability than other MAPs. On the other hand, PE package, with the lowest O_2 (1.96%) and the highest CO_2 (5.675%) concentrations, showed to have lower permeability than other MAPs. Creation and maintenance of optimum atmosphere in modified atmosphere package depend on O_2 and CO_2 permeability of the films and the respiration rate of the product (Kader et al., 1989). Anaerobic respiration is initiated in the tissue at very low O_2 (2% or lower) concentrations (Weichman, 1987). The O_2 concentration, which initiates anaerobic respiration, at the same time depends on product type, storage temperature and CO_2 concentration (Zagory et al., 1989). Low O_2 and high CO_2 concentrations in storage atmosphere reduce respiration rate besides ethylene production (Sandhya, 2010).

4.3. Petal color

Unstored flowers presented better petal color than stored flowers. Although L* value varied depending on storage duration and package type, an increase was observed in brightness at the end of storage in comparison to the control group. At the end of storage, the flowers in Smartbag® were brighter than the flowers in other packages (MAP) and those in PE were duller. In the present study, L* and b* values varied depending on storage duration and package type whereas they increased in comparison to the initial values but a* value decreased. Similar results were reported by Taş (2007) in citrus fruits (Grapefruit and Orange).

4.4. Sensory evaluation

The scores given to appearance, mould formation and odor attributes of the flowers in all MAPs decreased with increasing storage duration. At the end of storage, the worst sensorial scores were obtained from Xtend® and Smartbag® packages while the best sensorial score was obtained from PB + SF followed by PE package. Remon et al. (2000) reported that the fruits with high CO_2 concentration in the packages appeared better in some cherry cultivars stored in modified atmosphere packages. It is considered that higher CO_2 concentrations in PB + SF and PE packages, where the best sensorial scores were obtained at the end of storage among the packages, than the other two packages in the present study enabled the flowers to appear better. Furthermore, gas compositions in the packages may also vary depending on product type, package type and permeability as well as storage conditions and duration. The present study indicated that positive results in terms of attributes such as oil yield and quality might be obtained from the flowers in the packages, which were granted with scores below acceptable limit in terms of sensorial attributes. The flowers with bad sensorial scores can be utilized in order to obtain essential oil since oil rose flowers are not products that are directly eaten by people unlike fruits and vegetables. Nevertheless, in fruits and vegetables, the products, scored under acceptable limit in sensorial evaluations, are expressed as unmarketable and discarded.

4.5. Essential oil content

In the present study, oil content decreased significantly with increasing storage duration. The oil contents obtained from the petals stored for 10 days yielded results that were close to the control group whereas there was higher decrease in the oil contents during storage periods of 20 days and during the following storage periods. Likewise, Baydar et al. (2008a) reported that the oil content (0.010%) in the flowers stored at +4 °C for 4 weeks decreased by 66.7% in comparison to the oil content (0.035%) obtained from the petals distilled immediately. In the study, the lowest loss of oil content among the packages at the end of storage was in Xtend® (57.7%) while the highest loss was in PB + SF (91.3%). There has been no report on the conditions of cold storage of oil rose flowers so far. However, it has been reported that there is a high oil content in the petals distilled immediately after the harvest, that the rate of fermentation increases with increasing waiting duration for distillation and that oil content decreases significantly (Kazaz and Kelen, 1999; Baydar and Göktürk Baydar, 2005). The observation of the highest oil content in Xtend® among the packages may be due to the fact that this package has higher permeability than other packages.

4.6. Essential oil composition

It was reported that monoterpene alcohols were the main components of rose oil and that these components gave the characteristic odor to the oil (Garnero, 1982; Başer, 1992; Bayrak and Akgül, 1994). Among these monoterpene alcohols, citronellol, geraniol and nerol ranged from 25 to 50%, 8 to 16% and 3 to 12% in Turkish rose oils, respectively (Başer, 1992; Bayrak and Akgül, 1994) while they ranged from 22 to 55%, 14 to 18% and 5 to 10% in Bulgarian rose oils, respectively (Garnero, 1982; Kürkçüoğlu, 1988). In the study, citronellol in all package types during a storage duration of 10 days was higher than the control group (39.32%) but lower than the other storage durations and package types (apart from Xtend® during storage durations of 50 and 60 days). Nerol and geraniol in the stored petals were lower than those of unstored (control) petals. Similar results were reported by Başer (1992), Baydar and Göktürk Baydar (2005) and Baydar et al. (2008b). Hydrocarbons were reported to be the second highest components in rose oil after monoterpene alcohols (Bayrak and Akgül, 1994). In the present study, it was found that the concentrations of nonadecane, heneicosane and eicosane in the stored petals had higher scores than those of unstored petals. Baydar et al. (2008a) reported that the concentrations of hydrocarbon in oil rose flowers stored for various durations under storage conditions at 4 °C displayed higher scores than the petals distilled immediately whereas Baydar et al. (2008b) reported that the concentrations of hydrocarbon in oil rose flowers stored for various durations under room conditions displayed higher scores than the petals distilled immediately.

Rose oil acquired its best odor when citronellol/geraniol (C/G) ratio varied between 1.25 and 1.30 (Başer, 1992). In the present study, C/G ratio varied depending on storage duration and package type. In addition, all C/G ratios obtained from stored flowers were higher than the C/G ratio (1.67) obtained from unstored flowers (data were not given). Baydar and Göktürk Baydar (2005) reported that the C/G ratio in the petals distilled immediately was 0.56 whereas it was 10.30 in those distilled 36 h after the harvest. Kürkçüoğlu (1995) reported that C/G ratio increased depending on the waiting duration of petals. In the study, the data obtained for the chemical composition of rose oil differ from the lower and upper limit scores of both Turkish rose oils and Bulgarian rose oils. That variations in the chemical composition of rose oils may be due to factors such as location, ecological conditions, soil, harvesting conditions and postharvest waiting duration until distillation, transportation, preliminary processes, distillation technique and storage conditions (Tucker and Maciarello, 1988; Başer, 1992).

5. Conclusion

Best results in terms of all attributes examined in the study were obtained from the petals distilled immediately after the harvest (unstored). Nevertheless, short flowering period of oil rose, delivery of excessive amount of flowers to the factories in a short period of time and storage of these flowers at the factories for a long period of time without being subjected to distillation cause considerable decreases in oil yield and quality and, therefore, cause economic loss. It was concluded in the present study that the losses to occur in the event of storage of rose petals for up to 10 days in all package types particularly with respect to oil yield, oil quality and weight loss and the other attributes under examination may be minimized. Although close values to the storage duration of 10 days were obtained in some package types in storage durations of 20, 30, 40, 50 and 60 days in terms of oil quality, the specified storage durations did not display suitable values in terms of oil content, weight loss and other attributes.

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