Effects Of Different Packaging Applications On Fruit Quality Of Apricots

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Abstract : In this research it is aimed to determine the avaliblity of different packaging materials for Roxana, Hungarian Best and Bebeco apricot cultivars stored in modified atmosphere conditions. For this aim, after harvesting, apricots were packed with LDPE and PVC packaging materials and some apricots stored with none application called as control. Packed apricots was put in cold storage in 0°C and 95% relative humidity for 30 days. After storage, weight loss, fruit firmness, fruit skin colour, soluble solid content, titretable acidity, total sugars and taste were determined.
According to the data after 30 day of storage, LDPE and PVC apllications were found to improve not only all the quality parameters but also storage qualifications of the apricot fruits.

Keywords : Apricot, postharvest, fruit quality

Introduction

Apricot (*Prunus armeniaca* L.*)* is a Chinese originated stone fruit with climacteric characteristic. Although it is a hot mild climate fruit, it has a large production area over the world (Anonymous, 2008a). Apricot has a significant role with regard to human health; contain nine different sugars, eighteen free amino acid, high amounts of vitamin A, beta-carotene and high levels of potassium and iron elements (Anonymous, 2008b). Fresh fruits are available in Turkish markets from mid-May to end of August (Özçağıran at. al., 2005). Since stone fruits are prone to spoilage, apricot has a short post-harvest life under normal temperatures (Chambroy, 1993).

Crisosto et al. (1996) investigated fruit base color, amount of total soluble solids (TSS) and fruit firmness (FF) and found TSS rates of >10%, amount of titratable acids (TA) as (0,7-1,0 g/100g) FF values as (0,9-1,4 kg) for fresh fruits ready to be harvested. Researchers also stated proper storage temperatures as (-0,5)–(0)°C and relative humidity as %90-95.

Most of the world apricot production is consumed as fresh fruit. However, drying and processing are also available alternatives for apricot since it has a short period of harvest and fresh fruits are prone to spoilage in short time. About 20-25% of world production is dried. The remaining parts left from fresh or dried fruits are processed (Sobutay, 2003).

	2006	2007	2008
Turkey	460.182	557.572	716.415
Pakistan	177.266	240.192	325.779
Iran	280.000	280.000	280.000
Uzbekstan	235.637	230.000	265.000

Italy	221.994	214.573	205.493
Algeria	167.017	116.438	145.000
Japan	119.700	120.600	120.600
Morocca	129.440	105.234	113.216
Syria	98.538	112.738	112.738

Table 1. Apricot Production Values (ton)

Apricot *(Prunus armeniaca* L.*)* production is very common in Çanakkale Kepez region and production areas are increasing both in the region and the province. However, various problems exist in marketing and reaching to desired production potentials due to very short storage durations and easy spoilage of the fruits.

Turkey is the leading country in apricot production with 250-300 thousand tons of production. Province of Malatya meets almost 50% of Turkish apricot production. Neighboring province Elazığ is also another center for apricot production. Significant amount of apricots known as Malatya apricot actually come from Baskil town of Elazığ. About 90% of apricot produced in Malatya is dried and almost 90-95% of dried fruits is exported (Anonymous, 2007a and Sobutay, 2003).

Areas of utilization and levels of consumption should be increased both inside and outside of the country since it has several significant health functions. Therefore, apricot products should be diversified. Currently available products are fruit juices, jam and marmalades, jelly, ice-cream, delight, cookies, chewing gums, dried pulp and etc (Sobutay, 2003).

Although geographically distributed all around the world, apricot has larger areas of production around Mediterranean, Europe, Middle Asia, America and Africa continents.

There are 7 apricot regions in Turkey with almost 20-25% of world production. These regions are:

Malatya: Produces almost half of the country production and about all production is dried. Hacıhaliloğlu, Çöloğlu, İsmailağa, Hasanbey, Şekerpare, Alyanak, Kabaaşı, Yeğen, Tokaloğlu, Çataloğlu, Hacıkız, Soğancı, Paşa mişmişi, Mahmudun eriği, Kurukabuk and Turfanda are the important varieties of the region.

Elazığ-Erzincan: Produces for export. Tokaloğlu, Mahmud'un Eriği are important varieties of the region.

Kars-Iğdır: Produces for domestic markets, varieties are juicy and pulpy. Aprikoz (Şalak) and early Ağerik are the important varieties of the region.

Mut-İskenderun(Mediterranean): Produces mostly for domestic markets and partially for export. Tokaloğlu, Sahıt, Septik, Lutgani, Hırmanlıdırağı and Tekeler are important varieties of the region.

Sakarya-Bilecik (Marmara): Produces for domestic markets, fresh consumption and partially industry. Karacabey, Mektep, Ethembey, İmrahor, Tokaloğlu (Yalova) and Çekirge are important varieties of the region.

Aegean: Produces for fresh consumption. Yerli İzmir, Proyma, Çiğli, Tokaloğlu (İzmir), Malatya and Şam are important varieties of the region.

Central Anatolia: Produces for fresh consumption and industry. Slight sulphurization is performed in Ürgüp, Konya and Gürün. Wild apricot production is also carried out in the region to be used in fruit juice industry. Boğaz, İri bitirgen, Şekerpare altız and Tokaloğlu are important varieties of the region (Sobutay, 2003).

Modification of ambient atmosphere is carried out in two ways as 'passive' and 'active' in modified atmosphere packing (MAP). Passive modification is applied for fruit and vegetable like respirating products and active modification is applied for every kind of products (Üçüncü, 2000).

Providence of balanced gas composition in passive modification is a slow process. It is not always possible to succeed in control of O_2 ve CO_2 concentrations. However, providence of balanced gas composition can be supplied in short time with interventions in active modification (Floros, 1990).

Atmosphere composition and variation of this composition in passive modification method depend on respiration rates and characteristics of packaging materials. The material to be used for packaging should be able to provide a balance between O_2 consumed by the product and oxygen passed through the material. Similar balance should also be supplied between CO_2 produced by the products and

CO_2 passed through the material. The critical issue here is to provide the desired atmosphere composition for the product without any damage caused by O_2 or CO_2 (Geeson, 1984).

When the modified atmosphere is combined with proper temperatures, it will provide following benefits to reduce the loses during post-harvest processing and preservation of horticultural crops and fruits (Debney et al. 1980, Kader 1985):

- Provide supports for biochemical and physiological changes by slowing respiration, ethylene production, changes in product compounds and softening and slows down the repining.
- O_2 levels of around 8% and CO_2 levels of more than 1% reduce the ethylene sensitivity of the fruits.
- Reduces the physiological damages like chilling damages, punctuations and some other storage spoilages.
- Modified atmosphere has direct or indirect impacts over post-harvest pathogens and consequent spoilages. Some applications may reduce spoilages. For instance, increased CO_2 levels (10-15%) may significantly prevent Botrytis spoilage over strawberry, cherry and some other fruits.
- It is a useful method to control pests over some products.

Pala at. al. (1993), investigated effects of modified atmosphere (MA) on post-harvest life and quality of apricots. Fruits were brought to laboratory 12 hours after the harvest, cooled to 3,2°C with water, packed and stored. Low density polyethylene (LDPE) with 50µ thickness was used as packaging material. Packed products were divided into two groups; one group was exposed to passive and the other to active modification (%3 O_2, %3 CO_2). Quality parameters like form of fruits, pH, total soluble solids, titratable acidity, color, weight loss and sensual evaluations were measured. Measurements were made once in a week for six weeks. They found lower shelf lives for control fruits than MA applied fruits. Passive modification with 50µ thick LDPE at 0°C for 6 weeks was selected as the best post-harvest preservation practice.

Berger et al. (1990) investigated the impacts of MA over cherries. Researchers harvested Bing and Lambert varieties as light red (75-100% colored) and dark red (100% colored). Closed packs provided 22 days preservation of cherries at 0 °C. They found that MA didn't have any negative impacts on taste and provided 2 days extra shelf life in addition to preservation period.

Herregods (1992) preserved cherries under MA conditions for 20 days and observed that increasing CO_2 levels in packages prevented mold development. While mold development was 7% in control fruits, it was 3,7% with 30µ LDPE, 1,2% with 50µ LDPE and 0% with 70µ LDPE.

Similarly, Ağaoğlu at. Al. (1992) investigated the effects of different packaging materials on cold storage of some plum varieties. Perforated and non-perforated polyethylene, perforated and non-perforated polypropylene were used as packaging material for "Stanley" and "d'Agen" plum varieties. Fruits were stored at -1 °C' with 80-90% relative humidity and quality parameters were measured once in every two weeks. They observed decreased fruit firmness and increased weight loss. Package material had an effect on weight loss. Effect of package material varied based on the variety of plums but provided better results than control treatments. Researchers recommended non-perforated polyethylene package as the best material.

Özkurt (1993) studied MA preservation of J.H.Hale peach, Stanley plum, Early Burlat cherry varieties with limited post-harvest duration. MA was created with PE (35µ), PP(12µ) and PVC (80µ) package materials. It was observed that preservation duration extended from 2-6 to 6 weeks for peaches, from 2-6 weeks to 6-7 weeks for plums and from 2 weeks to 4-5 weeks for cherries. Also, all three fruit varieties preserved their harvest freshness throughout the storage duration.

Similar studies were carried out during the years 2003 and 2004 for Hayward variety of kiwifruit by using 3 different package type (consumer package, classical package, and modified package) to preserve the quality of the products and to extend the duration of preservation. Packed fruits were stored at 0 ^{o}C temperature and 90–95% relative humidity. A decrease was observed in weight loss with modified package. However, weight loss increased with classical package. Fruit peel thickness, fruit firmness, vitamin C and titratable acid levels generally decreased during cold storage. Soluble solids increased during the preservation period. Effects of package types on fruit peel thickness were not found to be significant. Fungal spoilage elements were higher in fruits with modified package than the others. Fungal spoilage decreased in consumer package. Color brightening in green color of fruit pulp and red color of fruit peel were observed at the end of storage duration. Taste characteristics of fruits decreased during the storage. It was concluded that Hayward variety kiwifruits could be preserved for 6 months in modified package and 5 months in consumer and classical package (Namdar, 2005).

In another study, 6 month cold storage and 15 days shelf life of Hicaznar pomegranate variety were investigated. Fruits were covered with stretch film (12μ) and MAP (8μ). Packaging provided better preservation than control treatments. Considering visual quality and fungal spoilages, it was concluded that fruits with MAP application could be stored for 1 year 3 months and fruits with stretch film application could be stored for 1 year 4 months (Bayram, 2007).

A similar study was carried out to determine the effects of modified atmosphere packages (MAP) in extending the storage life of Hicaznar variety. Fruits were harvested at the best proper time and divided into three groups. The first group fruits were put into classical plastic. Second group fruits were wrapped with easily supplied Xtend®. The third group fruits were stored as control treatment without any wrapping. All fruits were stored at 6^{o}C temperature and 90-92% relative humidity. Weight lose, amounts of fruit juice, titratable acid, TSS, peel thickness and peel color parameters were measured at every 45 days. Beside them, fungal spoilages, physiological spoilages, changes in CO_2 and O_2 densities of packages were also recorded. It was concluded that MAP packages extended the storage duration of Hicaznar variety, decreased the weight loss and slowed down the peel thickening (Gözlekci et al., 2005).

A research was carried out for Hayward variety kiwifruits stored at 0°C temperature and 90–95% relative humidity. Fruits were put into small and medium polyethylene (PE) bags with different thicknesses and bags were closed up. Polyethylene bags used under modified atmosphere conditions reduced weight loss, spoilage and fruit firmness and preserved taste and quality of fruits for 6 months (Manopoloulou et al. 1997).

Zutkhi ve Ben-Arie (1990) stored Fuyu variety of persimmon fruits under modified atmosphere conditions. Fruits packed with 0,06 and 0,08 mm polyethylene and stored at 0°C. The fruits with maximum storage duration of 6 weeks were able to preserve their quality for 18 weeks under MA.

In this study, different packaging materials were used and different Passive MAP applications were carried out to extend the storage duration of “Hungarian Best”, “Bebeco” and “Roxana” apricot varieties and the best practice was tried to be determined. These varieties are produced at ‘Apricot Adaptation Parcels’ of Dardanos campus of ÇOMÜ Agricultural Faculty. They are highly adaptive to region and high market value both in Turkish and world markets. Results of this research will also be significant for fruits similar to apricot (peach, nectarine, plum) and results will also be directly used by local producers in practice and will provide economical gains for local economy.

Material and method

Material

Apricot fruits of this research were supplied from 7 year old fruit trees at ‘Apricot Adaptation Parcels’ of Dardanos campus of ÇOMÜ Agricultural Faculty. Tree spacing at these parcels is 5x5 m. Varieties of “Roxana”, “Bebeco” and “Hungarian Best” were used as plant material in this study. Harvest dates were 1st of July for “Hungarian Best”, 26th of June for “Bebeco” and 28th of June for “Roxana”.

Method

Randomized block design with three factors were used for experiments and 20 fruits were used in each replication. Data were statistically analyzed by using two-ways variance analysis and LSD test with 5% significance level. Minitab 15 statistical software was used for statistical analysis.

Post-Harvest Modified Atmosphere Package (MAP) applications were implemented for fruits of 3 different varieties. Following modified atmosphere applications were implemented over MAP applied groups respectively;

1. Modified atmosphere packaging application with low density polyethylene (LDPE) based Xtend supplied by Stepac Co.

2. Modified atmosphere packaging application with stretch film based Polyvinylchloride (PVC) supplied by Rotopak Co.

Changes in fruit base color were determined by Minolta CR400 color measurement device; changes in fruit flesh firmness were determined by “Effe- gi” type hand penetrometer; changes in total soluble solids were determined by ”Atago Pal 1” digital refractometer; changes in titratable acid amounts were determined by “İnolab pH 720” pH meter. Total sugar was determined in accordance with Ross (1959) dinitrophenol method. Sensory parameter of taste was evaluated out by 5 people testing team taking the appearance, aroma, sourness, and taste into consideration. Weight loss values were determined by

weighing “Sartorius” 0,01 g sensitive balance. MAP gas composition measurements were carried out daily by “PBI Gas Dansensor”.

Results and Discussion

Fruit Skin Color (°h)

Fruit skin colors were found to be significant with regard to cultivars. The lowest value was obtained from Roxana, it was followed by Hungarian best and Bebeco, and they all placed statistically in the same group. Effects of storage duration and package applications provided non-significant differences over fruit skin color.

Cultivar	Treatment	Storage Time (Day)		Cultivar Mean	Treatment Mean
		0	30		
Hungarian Best	Control	1,3973	1,3275	1,3736 b	Control
	PVC	1,3973	1,3425		
	LDPE	1,3973	1,3799		0,9884
Bebeco	Control	1,5159	1,4736	1,5029 a	PVC
	PVC	1,5159	1,4984		
	LDPE	1,5159	1,4979		1,0339
Roxana	Control	0,1214	0,0950	0,1495 c	LDPE
	PVC	0,1214	0,3278		
	LDPE	0,1214	0,1104		1,0038
Storage Time Mean.		1,0115	1,0059		
LSD (0,05)		NS		0,06533	NS
Significiant degree				*	

Table 2. Changes in fruit skin color of Hungarian Best, Bebeco and Roxana stored within different package materials.
LSD (0,05) Cultivar*Treatment*Time: NS

Fruit Firmness (FF-Kg)

Fruit firmness of control fruits and fruits with PVC package were lower than the others and they were placed in the same group. The best results were obtained from fruits with LDPE package.

Cultivar	Treatment	Storege Time (Day)		Cultivar Mean.	Treatment Mean
		0	30		
Hungarian Best	Control	1,0197 d	0,4930 f	0,8015 c	Control
	PVC	1,0197 d	0,6003 e		
	LDPE	1,0197 d	0,6564 e		1,2229 b
Bebeco	Control	1,8969 a	1,4298 c	1,6565 a	PVC
	PVC	1,8969 a	1,3131 c		
	LDPE	1,8969 a	1,5055 bc		1,2141 b
Roxana	Control	1,9683 a	0,5295 e	1,4288 b	LDPE
	PVC	1,9683 a	0,4862 e		
	LDPE	1,9683 a	1,6518 b		1,4498 a
Storage Time Mean.		1,6283 a	0,9628 b		
LSD (0,05)		0,06767		0,08288	0,08288
Significiant degree		*		*	*

LSD (0,05) Cultivar*Treatment*Time: 0,2030

Table 3. Changes in FF values of Hungarian Best, Bebeco and Roxana apricot varieties stored within different package materials (kg)

The highest softening was obtained from Hungarian best variety and PVC and LDPE packaging materials were able to preserve fruit firmness the best. This may be considered as a reaction against packaging material under the effects of variety characteristics. A general decrease was observed in fruit firmness of all treatments at the end of 30 days storage. It was seen that LDPE application yielded best results with regard to fruit firmness preservation.

Total Soluble Solids (TSS, %)

The highest TSS values were obtained from control treatment, TSS values of fruits with PVC and LDPE packaging material were lower than control fruits and they were placed statistically in the same group. Lower TSS values of PVC and LDPE indicate that these materials were good for preservation of these fruits.

Cultivar	Treatment	Storage Time (Day)		Cultivar Mean	Treatment Mean.
		0	30		
Hungarian Best	Control	11,987 de	14,242 a	12,604 a	Control
	PVC	11,987 de	12,383 cd		
	LDPE	11,987 de	13,040 b		11,970 a
Bebeco	Control	10,710 hi	12,865 bc	11,246 b	PVC
	PVC	10,710 hi	11,260 fg		
	LDPE	10,710 hi	11,220 fgh		11,303 b
Roxana	Control	10,413 i	11,601 ef	10,867 c	LDPE
	PVC	10,413 i	11,065 gh		
	LDPE	10,413 i	11,297 fg		11,445 b
Storage Time Mean		11,037 b	12,108 a		
LSD (0,05)		0,1704		0,2087	0,2087
Significiant Degree		*		*	*

LSD (0,05) Cultivar*Treatment*Time: 0,2030

Table 4. Changes in TSS values of Hungarian Best, Bebeco and Roxana apricot varieties stored within different package materials (%)

The highest value was obtained from Hungarian Best variety and it was followed by Bebeco and Roxana and they all were placed statistically in the same group. An increase was observed in TSS values after 30 days of storage with regard to initial values. The highest increase was observed in Hungarian Best variety. Varieties of Bebeco and Roxana had slight increases in TSS rates and they were better than Hungarian Best variety with regard to TSS.

Increases were observed in TSS values after 30 days storage duration. LDPE and PVC had lower values than control treatment. However, fruits of control treatment with the best averages of TSS were not found to be biochemically in good state and it was thought that collapse in fruit increased the TSS values.

8. TITRATABLE ACIDITY (TA %G)

Based on fruit analysis and statistical analysis, the lowest TA values were obtained from PVC packaging material and it was followed by control treatment and LDPE material. Control treatment and PVC were placed in the same statistical group.

Cultivar	Treatment	Storage Time (Day)		Cultivar Mean.	Treatment Mean
		0	30		
Hungarian Best	Control	1,5144 a	1,1377 c	1,3787 a	Control
	PVC	1,5144 a	1,1993 c		
	LDPE	1,5144 a	1,3918 b		1,2334 b
Bebeco	Control	1,1095 cd	0,9802 e	1,0515 b	PVC
	PVC	1,1095 cd	0,9760 e		
	LDPE	1,1095 cd	1,0242 de		1,2163 b
Roxana	Control	1,5161 a	0,9824 e	1,3520 a	LDPE
	PVC	1,5161 a	1,1424 c		
	LDPE	1,5161 a	1,4387 ab		1,3325 a

Storage Time Mean	1,3800 a	1,1414 b		
LSD (0,05)	0,03119		0,03820	0,03820
Significiant Degree	*		*	*

LSD (0,05) Cultivar*Treatment*Time: 0,09357

Table 5. Changes in TA values of Hungarian Best, Bebeco and Roxana apricot cultivars stored within different package materials (% g)

With regard to varieties, the lowest value was obtained from Bebeco and it was followed by Roxana and Hungarian Best varieties. A decrease was observed in TA value after 30 days storage. Taking tasting values into consideration, it was concluded that LDPE and PVC provided positive results with regard to fruit aroma and biochemical activity. Again, higher averages in control treatment reflect the metabolism of collapsing fruit.

Total Sugars (g/100g)

With regard to total sugar, variety, application, time-application and time-variety interactions were found to be significant. Hungarian Best had the lowest total sugar value with 1,46 g/100g. Total sugar value of Roxana was 2,53 g/100g and Bebeco had the highest total sugar value with 3,15 g/100g

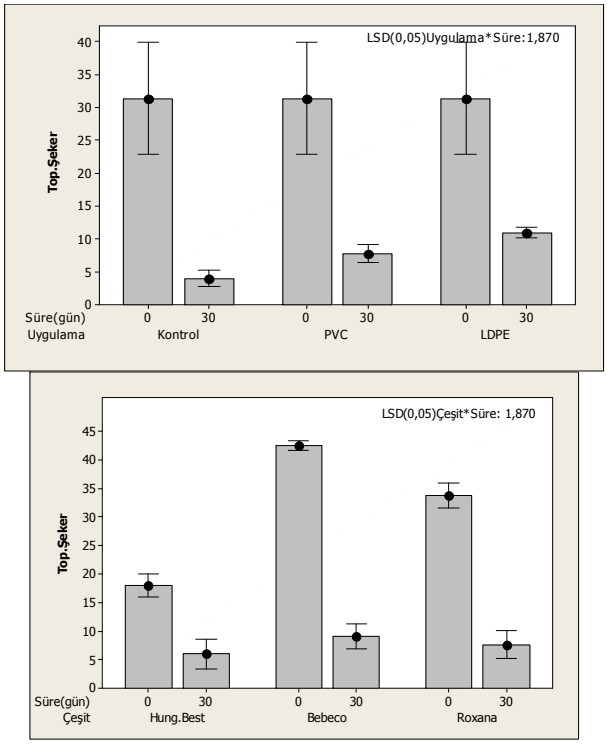

Figure 1. Changes in total sugar contents of of Hungarian Best, Bebeco ve Roxana apricot varieties stored within different package materials with regard to time-application and time-variety interactions (%g).

With regard to applications, fruits of control treatment had the lowest total sugar value with 2,16 g/100g. Fruits of PVC and LDPE package material had higher total sugar values than fruits of control treatment. The highest value was observed in LDPE material with 2,59 g/100g. Total sugar value of fruits packed with PVC material was 2,39 g/100g.

With regard to time-application, initial value of all treatments before storage was 3,84 g/100g. This value decreased to 0,49 g/100g in fruits of control treatment after 30 days of storage and this was a significant difference. The value of fruits packed with PVC material decreased to 0,94 g/100g. The

difference was lower in fruits packed with LDPE material than the other treatments and it was 1,.34 g/100g after 30 days of storage.

Tasting Test (scale of 1-5)

Ratings of a jury composed of 5 people and statistical evaluations indicated significance of application, variety, and time-application interaction.

Cultivar	Treatment	Storage Time(Day)		Cultivar Mean	Treatment Mean.
		0	30		
Hungarian Best	Control	2,9333	3,4667	3,3333a	Control
	PVC	2,9333	3,7333		
	LDPE	2,9333	4,0000		3,0111c
Bebeco	Control	3,1333	2,7333	3,1889b	PVC
	PVC	3,1333	3,2667		
	LDPE	3,1333	3,7333		3,2556b
Roxana	Control	3,1333	2,6667	3,1889b	LDPE
	PVC	3,1333	3,3333		
	LDPE	3,1333	3,7333		3,4444a
Storage Time Mean		3,0667b	3,4074a		
LSD (0,05)		0,06859		0,08401	0,08401
Significiant Degree		*		*	*

LSD (0,05) Cultivar*Treatment*Time: NS

Table 6. Changes in tasting test ratings of Hungarian Best, Bebeco and Roxana apricot cultivars stored within different package materials (scale of 1-5)

With regard to varieties, Hungarian Best had the highest value and varieties of Bebeco and Roxana had the same values. Bebeco and Roxana were placed in the same group and Hungarian Best was placed in a different group. With regard to applications, fruits of LDPE material had the highest value and it was followed by PVC and control treatment. They all placed in different groups. The best results were obtained from LDPE packaging material. An increase was observed in taste values after 30 days of storage.

Weight Loss (g)

With regard to varieties, Bebeco had the highest weight loss. Hungarian Best and Roxana had lower weight loss values than Bebeco and they were placed in the same statistical group. With regard to applications, fruits of control treatment had the highest weight loss values than fruits of PVC and LDPE packaging materials. Weight loss of PVC and LDPE packed fruits were very close to each other and they were placed in the same group.

	Control	PVC	LDPE	Mean	LSD
Hungarian Best	7,070 b	0.608 b	0,704 c	2,7939 b	0,5135
Bebeco	14,565 a	0,728 c	0,662 c	5,3183 a	
Roxana	7,325 b	0,614 c	0,469 c	2,8029 b	
Mean	9,6532 a	0,6503b	0,6116b		
LSD	0,5135				
Significiant Degree	*			*	

(LSD 0,05)Cultivar * Trearment : 0,8894

Table 7. Changes in weight loss values of Hungarian Best, Bebeco and Roxana apricot cultivars stored within different package materials (g)

MAP Gas Composition (%)

Daily MAP gas composition measurements were carried out by "PBI Gas Dansensor" and they were presented graphically as O_2 % and CO_2 % in Figure 2.

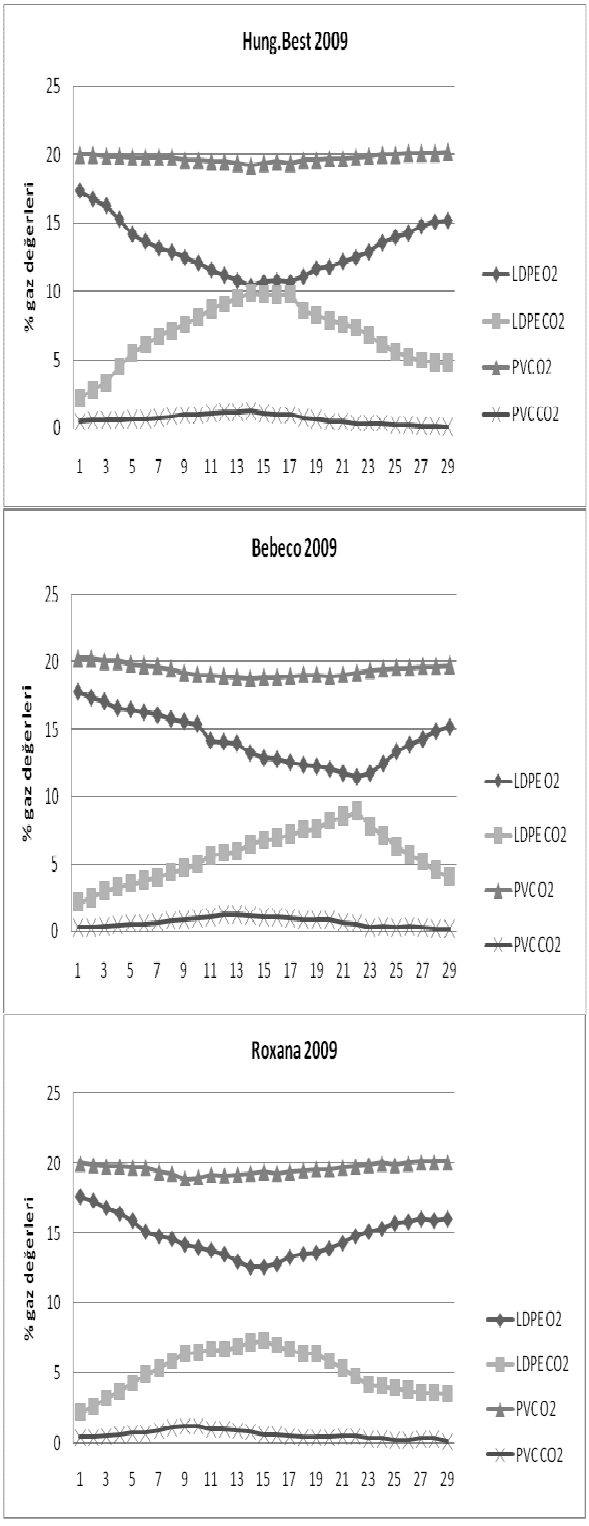

Figure 2. Changes in MAP gas compostion of Hungarian Best, Bebeco, Roxana apricot cultivars.

Conclusion and Recommendations

Packaging materials applied for apricots in this study yielded positive results with regard to investigated quality parameters. The differences especially in fruit skin color, fruit taste and fruit firmness provided by packaging materials compared to control treatment were remarkable. Consumers directly look for these quality parameters. On the other hand, weight loss can be prevented by packing fruits with LDPE and PVC materials. This is an important parameter for profitability of the producer. With regard to TSS, TA and total sugar values, packaging applications yielded positive results. These packaging applications can be considered as a preferable application to provide longer durations of storage and consequently supplying to markets at higher prices and increasing the profitability.

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