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Examination of some physiological and biochemical changes based on ripening in fruits of different types of apricots

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This study was performed to determine some of the physiological and biochemical changes that occurred during ripening period in fruits of different types of apricots. In the fruits of six types of apricots (Hasanbey, Canino, Turfanda Eskimalatya, Hacihaliloglu, Özal, and Levent) collected during green, mature green and ripe periods, amounts of total soluble solids (TSS) (Brix°), titratable acidity, chlorophyll a (Cha), chlorophyll b (Chb) and total chlorophylls (Ch) were determined. During ripening, the highest and lowest increase in TSS occurred in apricot types called 'Hacihaliloglu' and 'Turfanda Eskimalatya', respectively. In all three ripening periods, it was found that 'Hacihaliloglu' had the lowest acid content. During ripening, decreases in amounts of Cha, Chb and Ch were observed. Differences between apricot types in terms of decrease in chlorophyll amounts was detected and the highest difference occurred in apricot type called 'Turfanda Eskimalatya.'

Key words: Apricot, ripening, Brix, chlorophyll.

INTRODUCTION

Although commercial apricot production in the world involves quite extensive areas including Asia, Europe and America, worldwide apricot production is extremely low. According to the results of the World Agriculture Organization, worldwide fresh apricot production varies between 3 to 3.5 million tons (Anonymous, 2011). Turkey is the first producer of fresh and dried apricot, followed by Iran, Pakistan, Uzbekistan, France, Italy and Spain. In Turkey, apricot production is about 650,000 tons (Anonymous, 2010).

Like in many other fruit types, fruit development in apricot starts with flowering. After pollination and fertilization, developments starting in ovule spread to other tissues. Apricot fruit has double-sigmoid growth curve. In the fruit, there are three different developmental stages that are first fast, then slow and fast again lastly (Karacali, 1990).

Ripening of fruit includes a serial complex biochemical, physiological and structural changes such as starch hydrolysis, degradation of chlorophyll, production of carotenoid, anthocyanin and phenolic substance, accumulation of sugar and organic acid, modifications in structures and compositions of cell wall polysaccharides, color, taste and texture changes (Speirs and Brady, 1991; Giovannoni, 2001, 2004; Gulao and Olivera, 2008; Borsani et al., 2009).

First observable sign of ripening is the color change due to degradation of chlorophyll (Seymour et al., 1993). During ripening, while chlorophyll amount in fruit tissues decreases quickly, amount of carotenoid increases (Merzlyak et al., 1999). Chloroplasts found in green fruits are converted into chromoplasts by degradation of

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chlorophylls and carotenoid synthesis during progress of ripening (Hortensteiner, 2006). While surface color of fruit is initially green, it starts to be yellow with ripening due to degradation of chlorophyll (Bureau et al., 2009).

Fruit size, titratable acidity and total soluble solids (TSS) content depend on type, environment and cultivation conditions (Kingston, 1992). Changes in TSS are quite important for fruit taste development. In most fruits, ripening and fruit quality are determined by sugar content (Villanueva et al., 2004).

High acid content generally reduces fruit quality; however, intermediate acid concentration causes tastier fruits (Silva et al., 2004). Different organic acids are found in different fruit types. For example, citric and malic acids are basic organic acids found in cirtus and melon, and apple and loquat, respectively (Yamaki, 1989; Flores et al., 2001; Chen et al., 2009). Although titratable acidity of fruits decreases during different ripening periods, their pH and TSS increase (Jiménez et al., 2011).

In this study, amounts of TSS, titratable acidity, chlorophyll a (Cha), chlorophyll b (Chb) and total chlorophyll (Ch) were examined in six apricot types whose fruit samples were collected during green, ripe-green and ripe periods.

MATERIALS AND METHODS

Plant material

The apricot samples used in this study were taken from apricot collection garden found in Malatya Inonu University, Apricot Research and Application Center. Green and mature green fruit samples were collected after 30 and 60 days before flowering, respectively, and ripe fruit samples were collected before harvest from early-ripening apricot types; Canino, Turfanda Eskimalatya, Hasanbey and Hacihaliloglu. By considering fruit developmental periods, green and mature green fruit samples were collected after 30 and 90 days before flowering, respectively, and ripe fruit samples were taken before harvest from late-ripening apricot types; Levent and Ozal.

Total soluble solid content (TSS)

TSS in fruits was measured of the juice obtained from the pulp of 10 fruits by digital Brix refractometer (Asma and Ozturk, 2005).

Titratable acidity

10 ml juice was completed to 100 ml with distilled water and titrated by 0.1 N NaOH until pH 7.0. Titration results were calculated in terms of malic acid (Cemeroglu, 1992).

Pigment analysis

Extraction and purification of pigments from fruit samples were performed by De-Kok and Graham (1989) method. 1 g of each sample was homogenized by grinding with 500 cc acetone for 5 min and left in shaking incubator for 30 min. After that, they were stored at +4°C for 24 h. After filtering the samples taken out from refrigerator and addition of 1/5 volume distilled water, they were left in shaking incubator for 15 min and centrifuged at 300 rpm for 10 min. Absorbance of supernatants was measured at 662 and 645 nm for Cha, Chb and total Ch and calculated by using following standard equation.

Statistical analysis

Statistical analysis was performed using SPSS 10.0 software. Duncan's test (1955) was used for significance control ($P < 0.05$) following variance analysis.

RESULTS AND DISCUSSION

Total soluble solid content (TSS, °Brix)

TSS contents of apricot types were found statistically similar in green and mature green periods ($P < 0.05$) (Figure 1). While the highest TSS was found in 'Hacihaliloglu' and 'Ozal' (1.9%), the lowest TSS was found in 'Levent' (1.2%) in green period, slight increase was observed in mature green period, the highest TSS was found in 'Canino' (3.0%) and the lowest TSS was observed in 'Ozal' and 'Hacihaliloglu' (2.5%) ($P < 0.05$). The fastest increase in TSS occurred in mature green period and it was found that the highest and the lowest rates of TSS were observed in 'Hacihaliloglu' (22.0%) and 'Turfanda Eskimalatya' (14.1%), respectively. During fruit ripening, the highest TSS increase was found in 'Hacihaliloglu' and the lowest increase was observed in 'Turfanda Eskimalatya'.

In the studies carried out with different fruit types, increase in TSS was reported during fruit ripening period (Wu et al., 2005; Karlidag and Bolat, 2007; Prinsi et al., 2011). Jiménez et al. (2011) stated that TSS in gulupa (*Passiflora edulis*) fruits increased from 13.5 to 17.4% during progress of ripening.

Titratable acidity

While titratable acid content in fruits is the highest in mature green period, it has the lowest content in ripe period (Figure 2). Statistically significant differences between acidity were not observed in green fruit samples collected from different apricot types after 30 days before flowering ($P < 0.05$). In this period, while 'Canino' (2.88%) and 'Hacihaliloglu' (1.94%) had the highest and the lowest acid contents, respectively, 'Canino' (3.11%) and 'Turfanda Eskimalatya' (2.97%) had the highest content and 'Hacihaliloglu' (1.99%) had the lowest acid content in mature green period. A significant decrease in acid contents of fruits was observed in ripe period ($P < 0.05$) and it was found that 'Canino' (1.16%) and 'Levent' (1.15%) had the highest acid contents and 'Hacihaliloglu' (0.45%) had the lowest content.

Nunes et al. (2009) reported that the acid content in fruits of guava (*Psidium guajava*) and plum (*Prunus*

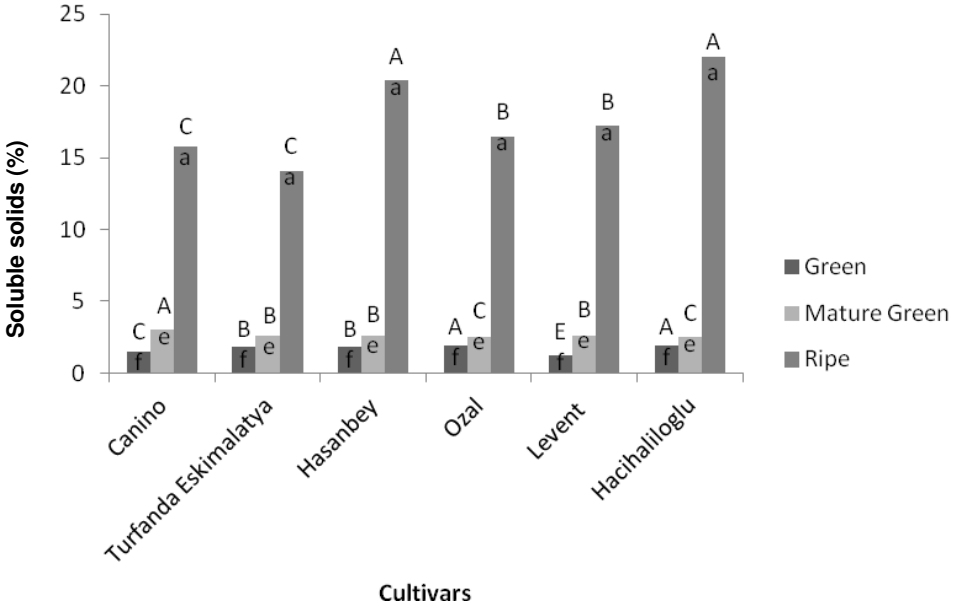

Figure 1. Soluble solids of different cultivars during the same ripening stages (capital letters) and during different ripening stages (small letters). Data followed by different letters are significiantly different from each other ($P < 0.05$) according to Duncan's test.

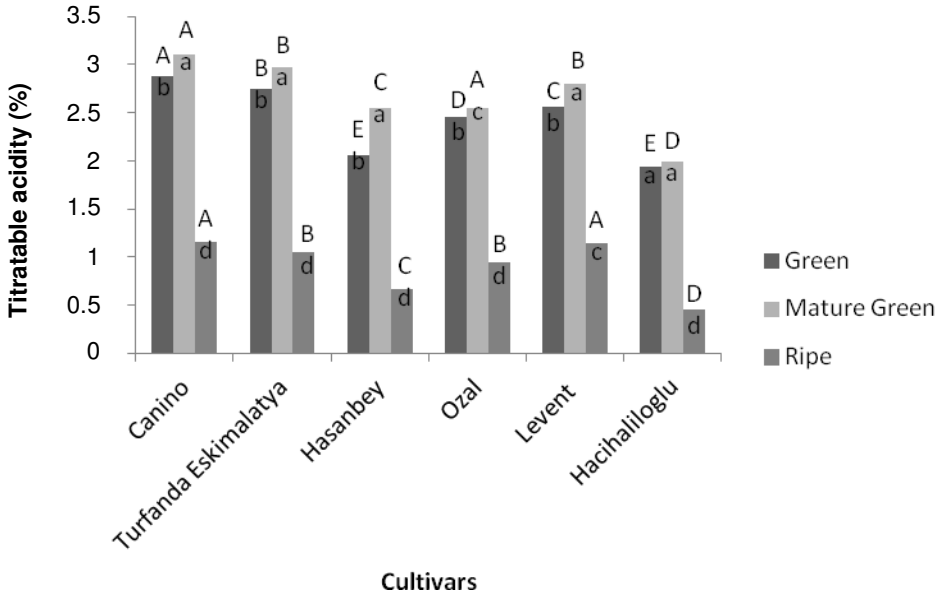

Figure 2. Titratable acidity of different cultivars during the same ripening stages (capital letters) and during different ripening stages (small letters). Data followed by different letters are significiantly different from each other ($P < 0.05$) according to Duncan's test.

domestica) initially increased significantly and then decreased during ripening period. Similarly, it is stated that acid content of gulupa (*P. edulis*) fruits which is 4.86% in green period, decreases to 2.51% in ripe period and the source of this decrease is organic acid consumption due to increased respiration rate in fruit during ripening period (Jiménez et al., 2011).

Pigment analysis

It was found that Cha, Chb and Ch contents in all apricot

Table 1. Mean Cha, Chb and ch contents of different cultivars during the same ripening stages (*unripe, #half ripe, ☼ripe) and during different ripening stages (letters on right).

Apricot cultivar	Ripening stage	Chlorophyll a (µg/g)	Chlorophyll b (µg/g)	Total chlorophyll (µg/g)
Hacihaliloglu	Green	$^{*b}1.69 \pm 0.003^{a}$	$^{*e}0.11 \pm 0.006^{a}$	$^{*c}1.80 \pm 0.003^{a}$
	Mature green	$^{\#c}1.26 \pm 0.003^{b}$	$^{\#c}0.03 \pm 0^{b}$	$^{\#c}1.29 \pm 0.003^{b}$
	Ripe	$^{\circ c}0.67 \pm 0.005^{d}$	$^{\circ c}0.008 \pm 0.01^{d}$	$^{\circ c}0.67 \pm 0.01^{d}$
Levent	Green	$^{*d}1.24 \pm 0.01^{a}$	$^{*b}0.89 \pm 0.04^{a}$	$^{*b}2.13 \pm 0.04^{a}$
	Mature green	$^{\#c}1.23 \pm 0.01^{a}$	$^{\#b}0.23 \pm 0.01^{b}$	$^{\#b}1.46 \pm 0.02^{b}$
	Ripe	$^{\circ a}1.15 \pm 0.008^{b}$	$^{\circ a}0.06 \pm 0.02^{d}$	$^{\circ a}1.21 \pm 0.01^{c}$
Hasanbey	Green	$^{*a}1.78 \pm 0.02^{a}$	$^{*c}0.44 \pm 0.0003^{a}$	$^{*a}2.22 \pm 0.02^{a}$
	Mature green	$^{\#a}1.55 \pm 0^{b}$	$^{\#a}0.30 \pm 0.01^{b}$	$^{\#a}1.85 \pm 0.01^{b}$
	Ripe	$^{\circ c}0.60 \pm 0.02^{d}$	$^{\circ d}-0.07 \pm 0.02^{d}$	$^{\circ d}0.53 \pm 0.01^{d}$
Turfanda Eskimalatya	Green	$^{*d}1.33 \pm 0.01^{a}$	$^{*a}1.16 \pm 0.003^{a}$	$^{*d}2.49 \pm 0.01^{a}$
	Mature green	$^{\#b}1.37 \pm 0.01^{a}$	$^{\#c}0.08 \pm 0.01^{c}$	$^{\#b}1.45 \pm 0.01^{a}$
	Ripe	$^{\circ d}0.56 \pm 0.01^{d}$	$^{\circ d}-0.01 \pm 0.003^{d}$	$^{\circ d}0.55 \pm 0.01^{d}$
Canino	Green	$^{*c}1.46 \pm 0.03^{a}$	$^{*b}0.81 \pm 0.04^{a}$	$^{*a}2.27 \pm 0.01^{a}$
	Mature green	$^{\#d}1.09 \pm 0.01^{b}$	$^{\#a}0.37 \pm 0.03^{b}$	$^{\#b}1.46 \pm 0.05^{b}$
	Ripe	$^{\circ d}0.58 \pm 0.02^{d}$	$^{\circ b}0.01 \pm 0.02^{d}$	$^{\circ c}0.59 \pm 0.02^{d}$
Ozal	Green	$^{*b}1.60 \pm 0.005^{a}$	$^{*d}0.27 \pm 0.003^{a}$	$^{*c}1.87 \pm 0.005^{a}$
	Mature green	$^{\#c}1.22 \pm 0.03^{b}$	$^{\#d}-0.08 \pm 0.03^{d}$	$^{\#d}1.14 \pm 0.01^{b}$
	Ripe	$^{\circ b}0.91 \pm 0.006^{c}$	$^{\circ c}0.006 \pm 0.02^{c}$	$^{\circ b}0.91 \pm 0.02^{d}$

Values are means ± standard deviation (SD) of three replications. Data followed by different letters are significiantly different from each other ($P < 0.05$) according to Duncan's test.

types displayed statistically significant decrease with ripening (Table 1) ($P < 0.05$). While Cha, Chb and Ch contents of fruits were found highest in green period, it had the lowest content in ripe period. While the one having the highest chlorophyll content among apricot types was 'Hasanbey' (1.78 µg/g) in green period, 'Turfanda Eskimalatya' (0.56 µg/g) was the one having lowest content in ripe period. It was determined that 'Turfanda Eskimalatya' having 1.33 µg/g Cha, 1.16 µg/g Chb and 2.49 µg/g Ch content in green period was the one that lost the most chlorophyll content and so that displayed more observable color change with ripening. In ripe period, its Ch content decreased to 0.55 µg/g. The type showing the lowest decrease in Ch content with ripening was 'Levent'. While Ch content of 'Levent' was 2.13 µg/g in green period, it decreased to 1.21 µg/g in ripe period. The type 'Levent' has light yellow fruit color in ripe period.

In most studies carried out, it was reported that degradation of chlorophylls and formation of chromoplasts with ripening were observed which was similar to our results (Beltran et al., 2005; Iglesias et al., 2008). Cox et al. (2004) stated that decrease in Cha and Chb levels in fruits of Hass avocado (*Persea americana)* occurred during ripening and anthocyanin concentration increased. Researchers reported that Cha content which was 0.43 mg g^{-1} in one period of the study decreased to 0.36 mg g^{-1} in last ripening period and Ch content decreased from 0.63 to 0.57 mg g^{-1}. In addition, total anthocyanin amount increased from 150 to 524 mg kg^{-1}. It was found that these pigment changes were related with surface and inside fruit color changes.

In the study carried out about ripening and chlorophyll changes in 5 apple types (Antonovk, Zhigulevskoe, Granny Smith, Golden Delicious and Renet Simirenko), Merzlyak et al. (2003) found that while chlorophyll contents were 11 nmol/cm^2 in apple types in green period, it decreased to 0.2 nmol/cm^2 with ripening. In the study, it was reported that Granny Smith had the highest chlorophyll content and the content decreased about 3 times in Antonovka and Golden Delicious types with ripening and storage.

Conclusion

In this study, it was determined that some physiological and biochemical changes and the relationship between this change and ripeness stages showed differences between different apricot types during ripening period. The

result showed that ripening apricot fruit is a process with stages well-differentiated in their physicochemical properties. During this process, TSS increased and titratable acid content decreased. This situation created the fruit characteristic taste. With ripening of fruits, degradation of Cha, Chb and Ch increased and fruit color displayed change from green to yellow and orange. It can be said that different varieties and different ripening stages have effects on these changes.

ACKNOWLEDGMENTS

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ABBREVIATIONS

TSS, Total soluble solids; **Cha,** chlorophyll a; **Chb,** chlorophyll b; **Ch,** total chlorophylls.

REFERENCES

Anonymous (2010). FAO Production Year Book, Rome, Italy.
Anonymous (2011). Agricultural Structure and Production. Turkish Statistical Institute, Turkey.
Asma BM, Ozturk K (2005). Analysis of morphological, pomological and yield characteristics of some apricot germplasm in Turkey. Gen. Res. Crop Evol. 52:305-313.
Beltran G, Aguilera MP, Rio CD, Sanchez S, Martinez L (2005). Influence of fruit process on the natural antioxidant content of Hojiblanca virgin olive oils. Food Chem. 89:207-215.
Borsani J, Budde CO, Porrini L, Lauxmann MA, Lombardo VA, Murray R, Andreo CS, Drincovich MF, Lara MV (2009). Carbon metabolism of peach fruit after harvest: changes in enzymes involved in organic acid and sugar level modifications. J. Exp. Bot. 60:1823-1837.
Bureau S, Renard MGC, Reich M, Ginies C, Audergon JM (2009). Change in anthocyanin concentrations in red apricot fruits during ripening. LWT - Food Sci. Technol. 42:372-377.
Cemeroglu B (1992). Fundamental Analysis methods for fruit and vegetable processing industry. Ankara, Turkey. P. 381.
Chen FX, Liu XH, Chen LS (2009). Developmental changes in pulp organic acid concentration and activities of acid-metabolising enzymes during the fruit development of two loquat (*Eriobotrya japonica* Lindl.) cultivars differing in fruit acidity. Food Chem. 114:657-664.
Cox KA, McGhie TK, White A, Woolf AB (2004). Skin colour and pigment Chl anges during ripening of “Hass” avacado fruit. Postharvest Biol. Tec. 31:287-294.
De-Kok L, Graham M (1989). Levels of pigments, soluble proteins, amino acids and sulfhydryl compounds in foliar tissue of Arabidopsis thaliana during dark induced and natural senesence. Plant Physiol. Biochem. 27:203-209.
Duncan DB (1955). Multiple range and multiple F Tests Biometrics. 11:1-14.
Flores FB, Martı´nez-Madrid MC, Sa´ nchez-Hidalgo FJ, Romojaro F (2001). Differential rind and pulp ripening of transgenic antisense ACC oxidase melon. Plant Physiol. Bioch. 39:37-43.
Giovannoni J (2001). Molecular regulation of fruit ripening. Ann. Rev. Plant Physiol. Plant Mol. Biol. 52:725-749.
Giovannoni JJ (2004). Genetic regulation of fruit development and ripening. Plant Cell. 16:170-180.
Gulao LF, Olivera CM (2008). Cell wall modification during fruit ripening: when a fruit is not the fruit. Trends Food Sci. Technol. 19: 4-25.
Hortensteiner S (2006). Chlorophyll degradation during senescence. Annu. Rev. Plant Biol. 57:55-77.
Iglesias I, Echeverria G, Soria Y (2008). Differences in fruit colour development, anthocyanin content, fruit quality and consumer acceptability of eight 'Gala' apple strains. Sci Hortic. 119:32-40.
Jiménez AM, Sierra CA, Rodríguez-Pulido FJ, González-Miret ML, Heredia FJ, Osorio C (2011). Physicochemical characterisation of gulupa (Passiflora edulis Sims. fo edulis) fruit from Colombia during the ripening. Food Res. Int. 44:1912-1918.
Karacali I (1990). Marketing and preservation of Horticultural Crops. Ege Uni. Agric. Fac. Pub. Bornova, İzmir (In Turkish) 494:413.
Karlıdag H, Bolat I (2007). Determination of the chemical and physical properties of some apricot cultivars growing at different altitudes in Malatya, Turkey. V. Nat. Hort. Congr. 1:782-785.
Kingston CM (1992). Maturity indices for apples and pears. Hort. Rev. 13:407-432.
Merzlyak MN, Gitelson AA, Chivkunova OB, Rakitin VY (1999). Non-destructive optical detection of pigment changes during leaf senescence and fruit ripening. Physiol. Plant. 106:135-141.
Merzlyak MN, Solovchenco AE, Gitelson AA (2003). Reflectance spectral features and non-destructive estimation of chlorophyll, carotenoid and anthocyanin content in apple fruit. Postharvest Biol. Tec. 27:197-211.
Nunes C, Santos C, Pinto G, Silva S, Lopes-da-Silva JA, Saraiva JA, Coimbra MA (2009). Effects of ripening on microstructure and texture of ‘‘Ameixa d’Elvas” candied plums. Food Chem. 115:1094-1101.
Prinsi B, Negri AS, Fedeli C, Morgutti S, Negrini N, Cocucci M, Espen L (2011). Peach fruit ripening: A proteomic comparative analysis of the mesocarp of two cultivars with different flesh firmness at two ripening stages. Phytochemistry 72:1251-1262.
Seymour GB, Taylor JE, Tucker GA (1993). Biochemistry of Fruit Ripening. Chapman and Hall, London.
Silva BM, Andrade PB, Goncalves AC, Seabra RM, Oliveira MB, Ferreira MA (2004). Influence of jam processing upon the contents of phenolics, organic acids and free amino acids in quince fruit (Cydonia oblonga Miller). Eur. Food Res. Technol. 218:385-389.
Speirs J, Brady CJ (1991). Modification of gene expression in ripening fruit. Aust. J. Plant Physiol. 18:519-532.
Villanueva MJ, Tenorio MD, Esteban MA, Mendoza MC (2004). Compositional changes during ripening of two cultivars of muskmelon fruits. Food Chem. 87:179-185.
Wu BH, Quilot B, Genard M, Kervella J, Li SH (2005). Chl anges in sugar and organic acid concentrations during fruit maturation in peaches, *P. davidiana* and hybrids as analyzed by principal component analysis. Sci. Hortic. 103:429-439.
Yamaki YT (1989). Organic acids in the juice of citrus fruits. J. Jpn. Soc. Hortic. Sci. 58:587-594.