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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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Abstract: This study was performed to determine the some physiological and biochemical changes 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, Levent) collected during green, mature green and ripe periods, amounts of TSS (Brixo), titratable acidity, chlorophyll a, chlorophyll b and total chlorophylls 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 chlorophyll a, chlorophyll b and total chlorophylls 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'.

Keywords: Apricot, Ripening, ^{0}Brix, Acidity, Chlorophyll

1. Introduction

Although commercial apricot production in the world involves quite extensive area 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 3-3.5 million tons [1]. Turkey is placed on the top of fresh and dried apricot production and Iranian, Pakistan, Uzbekistan, France, Italy and Spain follow Turkey. In Turkey, it is known that apricot production is about 650 thousand tons [2].

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 [3].

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 [4, 5, 6, 7, 8].

First observable sign of ripening is the color change due to degradation of chlorophyll [9]. During ripening, while chlorophyll amount in fruit tissues decreases quickly, amount of carotenoid increases [10]. Chloroplasts found in green fruits are converted into chromoplasts by degradation of chlorophylls and carotenoid synthesis during progress of ripening [11]. While surface color of fruit is initially green, it starts to be yellow with ripening due to degradation of chlorophyll [12].

Fruit size, titratable acidity and TSS content depend on type, environment and cultivation conditions [13]. Changes in TSS are quite important for fruit taste development. In most of fruits, ripening and fruit quality are determined by sugar content [14].

High acid content generally reduces fruit quality; however intermediate acid concentration causes tastier fruits [15]. Different organic acids are found in different fruit types. For example, citric acid and malic acid are basic organic acids found in Cirtus and melon; and apple and loquat, respectively [16, 17, 18]. Although titratable acidity

of fruits decreases during different ripening periods, their pH and TSS increase [19].

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

2. Material and Method

2.1. Plant Material

The apricot samples used in the 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.

2.2. Total Soluble Solid Content (TSS)

TSS in fruits was measured of the juice obtained from the pulp of 10 fruits by digital brix refractometer [20].

2.3. 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 [21].

2.4. Pigment Analysis

Extraction and purification of pigments from fruit samples were performed by De Kok and Graham (1989) method. 1 gram 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 +40C 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 nm and 645 nm for Chl a, Chl b and total Chl and calculated by using following standard equation [22].

2.5 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 [23].

3. Results and Discussion

3.1. Total Soluble Solid Content (TSS, ^{0}Brix)

TSS contents of apricot types were found statistically similar in green and mature green periods. ($P<0.05$) (Fig. 1). While the highest TSS was found in 'Hacihaliloglu' and 'Ozal' (1.9 %) and the lowest TSS was found in 'Levent' (1.2 %) in green period, slight increase was observed in mature green period and 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'

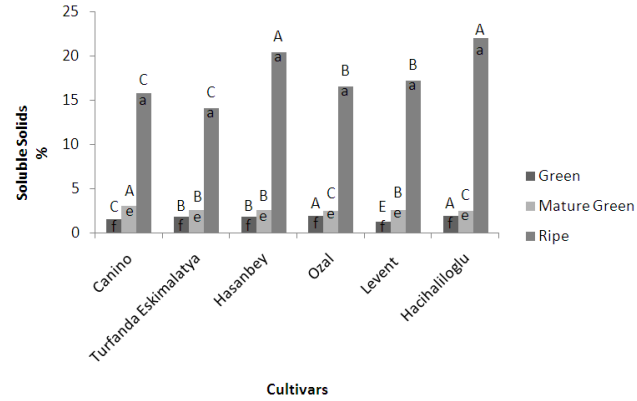

Figure 1. *Soluble solids of different cultivars during the same ripening stages (capital letters) and during different ripening stages (small letters). Data followed by different letters are significiantly different from each other ($P<0.05$) according to Duncan's test.*

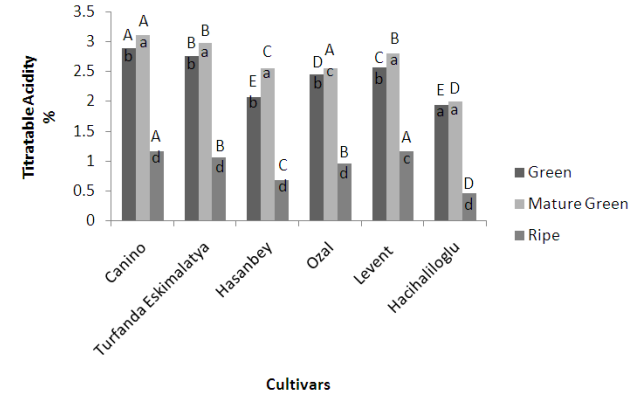

Figure 2. *Titratable acidity of different cultivars during the same ripening stages (capital letters) and during different ripening stages (small letters). Data followed by different letters are significiantly different from each other ($P<0.05$) according to Duncan's test.*

In the studies carried out with different fruit types, increase in TSS was reported during fruit ripening period [24, 25, 26]. Jimenez et al. (2011) stated that TSS in Gulupa (Passiflora edulis) fruits increased from %13.5 to %17.4 during progress of ripening [19].

3.2. Titratable Acidity

While titratable acid content in fruits is the highest in mature green period, it has the lowest content in ripe period (Fig. 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 were 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 domestica) initially increased significantly and then decreased during ripening period [27]. Similarly, it is stated that acid content of gulupa (Passiflora 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 [19].

Table 1. *Mean Chl a, Chl b and total chlorophyll contents of different cultivars during the same ripening stages (*unripe, #half ripe, ☼ripe) and during different ripening stages (letters on right)*

Apricot cultivars	Ripening stage	Chlorophyll a (µg/g)	Chlorophyll b (µg/g)	Total chlorophyll (µg/g)
	Green	*b1.69±0.003a	*e0.11±0.006a	*c1.80±0.003a
Hacihaliloglu	Mature green	#c1.26±0.003b	#c0.03±0b	#c1.29±0.003b
	Ripe	☼c0.67±0.005d	☼c0.008±0.01d	☼c0.67±0.01d
	Green	*d1.24±0.01a	*b0.89±0.04a	*b2.13±0.04a
Levent	Mature green	#c1.23±0.01a	#b0.23±0.01b	#b1.46±0.02b
	Ripe	☼a1.15±0.008b	☼a0.06±0.02d	☼a1.21±0.01c
	Green	*a1.78±0.02a	*c0.44±0.0003a	*a2.22±0.02a
Hasanbey	Mature green	#a1.55±0b	#a0.30±0.01b	#a1.85±0.01b
	Ripe	☼c0.60±0.02d	☼d-0.07±0.02d	☼d0.53±0.01d
	Green	*d1.33±0.01a	*a1.16±0.003a	*d2.49±0.01a
Turfanda Eskimalatya	Mature green	#b1.37±0.01a	#c0.08±0.01c	#b1.45±0.01a
	Ripe	☼d0.56±0.01d	☼d-0.01±0.003d	☼d0.55±0.01d
	Green	*c1.46±0.03a	*b0.81±0.04a	*a2.27±0.01a
Canino	Mature green	#d1.09±0.01b	#a0.37±0.03b	#b1.46±0.05b
	Ripe	☼d0.58±0.02d	☼b0.01±0.02d	☼c0.59±0.02d
	Green	*b1.60±0.005a	*d0.27±0.003a	*c1.87±0.005a
Ozal	Mature green	#c1.22±0.03b	#d-0.08±0.03d	#d1.14±0.01b
	Ripe	☼b0.91±0.006c	☼c0.006±0.02c	☼b0.91±0.02d

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.

3.3. Pigment Analysis

It was found that Chl a, Chl b and total Chl contents in all apricot types displayed statistically significant decrease with ripening (Table 1) ($P<0.05$). While Chl a, Chl b and total Chl contents of fruits were found the 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 Chl a, 1.16 µg/g Chl b and 2.49 µg/g total chl 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 total Chl content decreased to 0.55µg/g. The type showing the lowest decrease in total chlorophyll content with ripening was 'Levent'. While total chlorophyll content of 'Levent' was 2.13µg/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 [26, 28, 29]. Cox et al. (2004), stated that decrease in chlorophyll a and b levels in fruits of Hass avocado (Persea americana) occurred during ripening and anthocyanin concentration increased. Researchers reported that chlorophyll a content which was 0.43 mg g-1 in 1. period of the study decreased to 0.36 mg g-1 in last ripening period and total chlorophyll content decreased from 0.63 mg g-1 to 0.57 mg g-1. In addition, total anthocyanin amount increased from 150 mg kg-1 to 524 mg kg-1. It was found that these pigment changes were related with surface and inside fruit color changes [30].

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 11nmol/cm2 in apple types in green period, it decreased to

0.2nmol/cm2 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 [31].

4. Conclusion

In the 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 chlorophyll a, chlorophyll b and total chlorophyll 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.

Acknowledgements

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Abbreviations

TSS, Total soluble solids;
Cha, Chlorophyll a;
Chb, Chlorophyll b;
Ch, Total chlorophyll.

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