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Determination of Enzymatic Browning on Quinces (*Cydonia oblongo*) with Color Analysis

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Abstract: The aim of the study was to determine skin color change at the damaged quinces for marketing quality by using image analysis technique. Quality of quince fruit depends on size, color, shape and type of skin defects according to the international marketing standard. The first quality parameter is color of the food surface for consumers. This is critical in the acceptance of the product in the market. For this aim new harvested three different quince varieties were dropped from 60 cm height to the wood and plastic impact surfaces for enzymatic browning test. After the impaction, colour changes of damaged regions of each sample were determined with a colourmeter which based on L*a*b* measurement system. Change of color values were observed day by day with colourmeter. The enzymatic browning was determined clearly from colourmeter L*a*b* results and were evaluated statistically.
Key words: Mechanical damage, enzymatic browning, quince, color analysis

INTRODUCTION

Majority of fruit quality loss is caused by bruise damage due to dynamic and static impact loads. The factors causing damage on fruits are size of fruits, fall height of fruit, the kind of contact surface, the number of contact, contact energy and ripeness stage of fruit (Zarifneshat et al., 2010). Fruit texture is very sensitive because of that reason the fruit flesh can be easly damaged then the damaged region rot after they darken. The fresh fruit markets rely on external quality of products (Unay and Gosselin, 2006). A high quality fruit sample cannot include fruits affected by negative textural attributes (Arana et al., 2007).

Quince (*Cydonia oblongo*) is widely produced in Turkey. Nearly 110 000 tons quince have been produced in Turkey every year. In Turkey quince production is made densely specially in Umurbey and Kepez provinces of Çanakkale (Kuzucu and Sakaldas, 2008). Quality of quince fruit depends on size, colour, shape and type of skin defects according to the international marketing standards. The first quality parameter is colour of the food surface important for consumers. This is critical for acceptance of the product in the market. The colour of fruit surface is the first decision tool for consumers' acceptance or rejection of food products (Leon et al., 2006). Income from fruit and vegetables are affected by the quality of produce. Therefore, it is important to distinguish the colour of fruit from the non-changed ones (Xing et al., 2006). Computer vision has been successfully adopted for the quality analysis of food (Brosnan and Wen Sun, 2004). Industrial automated machine vision systems are already used for inspection of fruits according to colour.

Mendoza et al. (2006) worked on a computer imaging system which measured and captured standard sRGB colour, HSV and L*a*b* colour space of vegetable and fruit images. Ratule et al. (2006) were studied to characterize chilling injury development of 'Berangan' banana (*Musa* cv. Berangan) during storage at low temperature. 'Berangan' banana were stored at 5, 10 and 15 ^{o}C for 16 days to evaluate the degree of browning (DOB) and peel colour (L*, C* and h^{o}).

MATERIAL and METHODS

'Ekmek, Demir, Elma' quince varieties were selected for determination of skin colour changes. These samples were chosen randomly from newly harvested quinces. All dimensions of these products were measured with a caliper. Sinbo sks – 4507 model which is sensitive to 1 gr weight scale was used for weight measurement. Colour measurements were determined with Minolta Cr200 model colourmeter which is based on L*a*b* measurement system (Figure 1.). Minolta Cr200 model colourmeter was calibrated with a white reflective plate.

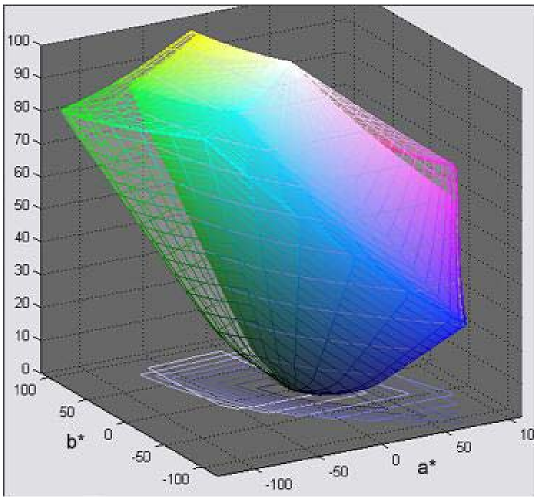

Figure 1. L*a*b* colour space.

A pendulum unit was constructed for impact tests. The unit designed for different drop heights so that quince could be easily dropped from 60 cm height.

Mechanical forces exerted on quinces in wooden and plastic crates during harvesting and the transport period from the harvest to market stage. Typical wooden crates as specified in Turkish Standard Instutition, TSE 3766, and widely used in fruit transport in Turkey (Acıcan et al., 2007). Two different surfaces were used for the impact tests which were taken from fruit boxes. One of them was 160x360x10 mm wood surface and the other was 200x200x1 mm plastic surface.

The relationships between the obtained data were examined in the MSTAT statistical program. Duncan's multiple range tests was used in order to determine the mean difference among variety, impact surface and day analyses for determining colour changes.

All quinces were dropped from 60 cm drop height on impact surfaces. After the impact, changes of colour value were evaluated. Impact surfaces were placed perpendicular to impact direction during test. Quinces were impacted from their cheek regions to measure the surface area efficiency. For this purpose 54 sample were impacted symmetric to their middle regions and 108 L*a*b* values were obtained. From each surface, 3 measurements were obtained with colourmeter and measurement averages were used as real colour value (Figure 2.).

Figure 2. Selection of L*a*b* sample points by using colourmeter

Change in colour was followed for 5 days and then average of 54 L*a*b* values were taken as day colour value. These values are presented in results and discussion section of the research.

The change in colour values was evaluated using the following equation (Equation 1.):

$$\Delta E^*=[(\Delta L^*)^2+(\Delta a^*)^2+(\Delta b^*)^2]^{1/2} \quad (1)$$

In this equation,

ΔE: Change in colour value

L*: Brightness value,

a*: Colour change from red to green,

b*: Colour change from yellow to blue.

RESULTS and DISCUSSIONS

The main problem during marketing for quince variety is enzymatic browning, leading to post-harvest physiological disorder. This physiological disorder may occur because of vegetation period, harvest time or storage conditions (Kuzucu and Sakaldas, 2008). Because of that reason locally produced quince variety test results were presented in this research.

Hardness of fruits was measured with a hand held penetrometers. Measurements of the quinces physical properties which were used for the tests are given in Table 1.

Table 1. Physical properties of quinces which were used for the tests.

Properties	Ekmek	Demir	Elma
Fruit diameter (mm)	76,58 ± 1,84	63,03± 2,19	59,46 ± 2,18
Weight (g)	178,63 ± 8,56	169,63± 8,86	101,88 ± 7,56
Geometric mean diameter (mm)	71,74 ± 2,33	60,19 ± 2,53	57,93 ± 1,29
Sphericaly (%)	97,42 ± 1,33	97,23 ± 2,45	96,88 ± 2,13
Hardness of fruit (kg)	11,79 ± 0,51	11,58 ± 1,31	10,75 ± 0,86

The impact tests that applied to the three quince varieties changed colour values. Average changes of colour values for each quince varieties for five days are presented in Table 2.

Table 2. Average colour value change for quince varieties.

	Ekmek	Demir	Elma
Days	**Avg. ΔE**	**Avg. ΔE**	**Avg. ΔE**
1. Day	70,49	73,42	68,17
2. Day	67,70	59,74	55,21
3. Day	68,15	62,42	51,11
4. Day	68,03	60,08	61,33
5. Day	65,99	60,96	51,02

Repeated ANOVA statistics was used for evaluating colour interaction between other variables. The first group of variables was 3 quince varieties. The second groups of variables were days. The third group of variables was wood and plastic impact surfaces. Duncan test was used for determining differences of variable groups. Results of interactions for each of L, a*, b*, values between the quince varieties, surfaces and days, L value were significant ($p<0.05$), interaction between the quince varieties and days, surfaces and days were significant ($p<0.01$), interaction between the quince varieties, surfaces and days for b value were significant ($p<0.05$). The interaction values are presented in Tables 3 - 6.

When the L*a*b* values of 'Ekmek' variety is reviewed, it can be concluded that L* value had important change from first impact for all surfaces, a* values had important change third day of the impaction, b* value had important change first day at plastic surface, additionally first and fifth days at wood surface.

Table 3. The interaction between the quince varieties, surfaces and days for L value.

Variable		V1 - S1		V1 - S2	
Day	**N**	**Mean**	**SE Mean**	**Mean**	**SE Mean**
0	18	73,78A	1,36	75,11A	1,54
1	18	48,00B	1,30	45,61B	2,02
2	18	43,94BC	1,30	44,89B	1,74
3	18	43,39C	1,54	46,61B	1,57
4	18	45,39BC	1,47	45,78B	1,43
5	18	43,44C	0,90	44,44B	1,35
Variable		**V2 - S1**		**V2 - S2**	
Day	**N**	**Mean**	**SE Mean**	**Mean**	**SE Mean**
0	18	78,61A	1,59	80,83A	2,06
1	18	50,33B	2,23	49,72B	2,52
2	18	42,78C	2,10	35,33C	1,74
3	18	44,00C	2,25	38,33C	1,97
4	18	41,72C	1,51	37,61C	1,27
5	18	43,72C	1,64	37,39C	1,82
Variable		**V3 - S1**		**V3 - S2**	
Day	**N**	**Mean**	**SE Mean**	**Mean**	**SE Mean**
0	18	79,55A	0,60	79,61A	0,63
1	18	38,00B	1,76	41,61B	2,63
2	18	29,67C	1,49	30,50D	2,28
3	18	25,44B	1,61	29,17D	2,41
4	18	34,50B	1,77	36,61C	1,74
5	18	24,06D	1,88	30,78D	2,23

In the table: V1: Ekmek variety, V2: Demir variety, V3: Elma variety, S1: Plastic surface, S2: Wood surface, N: Number of samples.

Table 4. The interaction between the quince varieties and days for a value.

Variable		V1		V2		V3	
Day	**N**	**Mean**	**SE Mean**	**Mean**	**SE Mean**	**Mean**	**SE Mean**
1	36	12,61AB	0,52	9,72A	1,16	28,22A	0,89
2	36	13,75A	0,52	10,69A	0,81	26,02B	0,64
3	36	13,22AB	0,54	10,36A	0,74	25,44B	0,66
4	36	9,86C	0,46	9,50A	0,76	24,75B	0,77
5	36	11,91B	0,49	10,52A	0,78	24,97B	0,81

In the table: V1: Ekmek variety, V2: Demir variety, V3: Elma variety, N: Number of samples.

Table 5. The interaction between the quince varieties and surfaces for b value.

Surface	N	Variable	Mean	SE Mean
S1	90	V1	12,73B	0,32
	90	V2	8,96C	0,44
	90	V3	27,58A	0,43
S2	90	V1	11,81B	0,36
	90	V2	11,35B	0,6
	90	V3	24,17B	0,49

In the table: V1: Ekmek variety, V2: Demir variety, V3: Elma variety, N: S1: Plastic surface, S2: Wood surface, Number of samples.

Table 6. The interaction between the quince varieties, surfaces and days for b value

Variable		V1 - S1		V1 - S2	
Day	**N**	**Mean**	**SE Mean**	**Mean**	**SE Mean**
0	18	64,11A	1,01	57,72A	1,77
1	18	51,89B	1,21	53,28B	1,42
2	18	50,33B	1,19	50,50BC	1,28
3	18	49,78B	1,32	49,89BC	1,20
4	18	50,11B	1,13	49,67BC	1,27
5	18	48,61B	0,87	48,61C	0,91
Variable		**V2 - S1**		**V2 - S2**	
Day	**N**	**Mean**	**SE Mean**	**Mean**	**SE Mean**
0	18	61,94A	1,37	62,17A	1,85
1	18	54,00B	1,02	51,83B	1,64
2	18	48,17C	1,54	45,11C	1,23
3	18	47,56C	1,95	43,72C	1,65
4	18	47,33C	1,27	44,56C	1,01
5	18	48,17C	1,45	42,72C	1,32
Variable		**V3 - S1**		**V3 - S2**	
Day	**N**	**Mean**	**SE Mean**	**Mean**	**SE Mean**
0	18	65,72A	2,07	62,17A	1,71
1	18	45,00B	1,54	47,78B	1,97
2	18	38,17C	1,57	41,17C	2,22
3	18	33,44D	1,84	37,39C	2,35
4	18	45,17B	1,89	46,50B	1,80
5	18	32,33C	2,12	38,00C	2,48

In the table: V1: Ekmek variety, V2: Demir variety, V3: Elma variety, S1: Plastic surface, S2: Wood surface, N: Number of samples.

For 'Demir' variety L* value had important change from first and second days for all surfaces, a* values had not important change for all days, b* value had important change first and second days for all surfaces. The L*a*b* values in 'Elma' variety was revealed that L* value had important change from first, second, third and fifty days at plastic surface, first, second, third days at wood surface, a* values had important change fist day of the impaction, b* value is depending on days and surfaces. L*a*b* values of 'Elma' variety had different color relations from other varieties because of brown regions at quince skin and the average of sampling spots. In the basis of flesh browning, it can be concluded that different ecologic conditions and harvest periods affects the flesh browning on quinces.

For the surface properties, wood surface creates more impacts on quinces than plastic surface because of material properties (Table 5).

CONCLUSIONS

Image analysis of the oxidation rate which were created after impact test is important for designing equipments and machines for classification, packaging, transportation and transmission. The results of these impaction tests indicated that the response enzymatic browning on quinces were dependent on the quince varieties, surfaces and days of the impact.

For the surface properties, wood surface creates more useful for quinces than plastic surface because of material properties. According to the results, plastic surface affects in a good way for quince surfaces which are harvested or processed for post-harvest.

In this research we have shown that image analysis technique can easily be used for determination of enzymatic browning degree on quinces and other agricultural products.

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