Türk Tarım ve Doğa Bilimleri Dergisi 7(2): 510–519, 2020
https://doi.org/10.30910/turkjans.725995

TÜRK
TARIM ve DOĞA BİLİMLERİ
DERGİSİ

TURKISH
JOURNAL of AGRICULTURAL
and NATURAL SCIENCES

www.dergipark.gov.tr/turkjans

Research Article

New Approaches on Measurement of Fruit Firmness For Fresh-Cut Products

Fatih Cem KUZUCU
Faculty of Agriculture, Department of Horticulture, Çanakkale Onsekiz Mart University, Çanakkale, Turkey
Corresponding author: fatihcem2005@hotmail.com

Received: 01.03.2020 Received in revised: 09.04.2020 Accepted: 09.04.2020

Abstract

Due to the heavy working conditions of the business world in today's conditions, changes have occurred in the habits of people consuming fruits and vegetables. It is also a fact that the people working in economically developed societies spend less time preparing food, eat at restaurants or take fast food home. Working individuals' tendency to purchase fruits and vegetables peeled, even chopped, shredded or grated, that is semi-processed -ready for consumption- is getting stronger due to reasons such as foodservice industry, cost, labor, and hygiene. For this reason, the fresh-cut fruit and vegetable sector has become the food sector with a rapid growth trend in recent years. The biggest problem in these products is the short shelf life after semi-finished product preparation processes and the deterioration in product quality during the sales process. Preservative solutions developed to protect the product quality are successful, however, the effects of these applications on fruit firmness cannot be measured accurately due to the deterioration of fruit integrity (slicing, chopping, grating, etc.) during product processing. In this study, it has been aimed to accurately determine the changes in fruit firmness during the preservation process of the fruits taken into the fresh-cut process by using specially developed apparatus (45, 60, 90° angled V-blocks assembly). The fruit integrity deteriorates due to the preservation of the fruit by slicing the fruits taken into the fresh-cut process; after this stage, the firmness measurement cannot be carried out stably in the analyses to be made for the change of the fruit quality. The blocks apparatus developed for this purpose can be used in order to more accurately determine the effects of the applications made for quality preservation in the process of storage and shelf life in fruits divided into 4-6-8 slices. In the study, the values obtained from the firmness measurements made with sliced fruits in apple, pear and quince species showed that the developed angled blocks apparatus gave more stable measurement values considering the standard deviation value and the variation created by the averages.

Keywords: Fruit firmness, fresh-cut, semi-processed product, V-blocks.

Fresh-Cut Uygulamalarında Meyve Eti Sertliği Ölçümü Üzerine Yeni Yaklaşımlar

Özet

Günümüz koşullarında iş dünyası çalışma şartlarının ağırlaşmasına bağlı olarak insanların meyve - sebze tüketme alışkanlıklarında da değişimler meydana gelmiştir. Ekonomik olarak gelişmiş toplumlarda çalışan kesimin yemek hazırlamaya daha az zaman ayırdığı, lokantalarda yemek yediği veya eve hazır yemek götürdüğü de bir gerçektir. Çalışan bireylerin özellikle gıda servis endüstrisi, maliyet, işçilik ve hijyen gibi nedenlerden dolayı meyve ve sebzeleri soyulmuş hatta doğranmış, parçalanmış veya rendelenmiş yani yarı işlenmiş olarak tüketime hazır bir şekilde satın alma eğilimleri giderek artmaktadır. Bu nedenle taze kesilmiş ve kullanıma hazır (Fresh-cut) meyve – sebze sektörü son yıllarda hızlı büyüme eğilimi gösteren bir gıda sektörü haline gelmiştir. Bu ürünlerdeki en büyük problem yarı mamul ürün hazırlama işlemleri sonrasında raf ömürlerinin kısa olması ve satış sürecinde ürün kalitesinde meydana gelen bozulmalardır. Ürün kalitesini korumaya yönelik geliştirilen koruyucu solüsyonlar başarılı olmakta ancak bu tip uygulamaların özellikle meyve eti sertliği üzerine olan etkileri ürün işleme sırasında meyve bütünlüğünün bozulmasından dolayı (dilimleme, doğrama, parçalara ayırma, rendeleme vb.) doğru olarak ölçülememektedir. Bu çalışmada taze kesim (Fresh-Cut) sürecine alınan meyvelerde muhafaza süreci sırasında meyve eti sertliğinde meydana gelen değişimlerin geliştirilen özel aparatlar (45, 60, 90° açılı V-takoz düzeneği) kullanılarak doğru bir şekilde tespit edilmesi amaçlanmıştır. Fresh-cut sürecine alınan meyvelerde meyvenin dilimlere ayrılarak muhafaza edilmesinden dolayı meyve bütünlüğü bozulmakta bu aşamadan sonra meyve kalitesinin değişimine yönelik yapılacak analizlerde sertlik ölçümü stabil şekilde gerçekleştirilememektedir. Bu amaçla geliştirilen takoz aparatları, 4-6-8 dilime ayrılmış meyvelerde depolama ve raf ömrü sürecinde kalite korunmasına yönelik yapılmış uygulamaların etkilerinin daha doğru saptanmasını sağlamak amacıyla kullanılabilecektir. Çalışmada, elma armut ve ayva türlerinde dilimlenmiş meyveler ile yapılan sertlik ölçümlerinden alınan değerler geliştirilen açılı takoz aparatlarının standart sapma değeri ve ortalamaların oluşturduğu varyasyon göz önüne alındığında daha kararlı ölçüm değerleri verdiğini göstermiştir.

Anahtar kelimeler: 01-03-.

Introductıon

In recent years, demand for freshly sliced horticultural crops has increased in line with socio-cultural changes and consumer awareness of fresh fruit and vegetable consumption. The fresh-cut fruits and vegetables processed at a minimum level are much more sensitive during storage and shelf life than other horticultural products. For example, bruising the products during the preparation stages such as peeling and slicing results in more water loss and discoloration. In addition to the enzymatic blackening, which varies according to the genetic structure of the species and varieties, pre-skin factors such as soil and climatic conditions and fertilization, processing and post-skin factors such as washing, cutting and storage can significantly affect the texture and color in freshly cut fruits and vegetables. In these products, the preservation of color that directly affects consumer preference in the marketing phase is very important (Güneş and Öz, 2014).

Especially, fresh-cut or fresh-chopped fruits and vegetables stand out with the feature of having a fresh and original aroma from other ready-to-eat products. In addition to the above-mentioned characteristics of fresh-cut fruits and vegetables, other factors such as being healthy and very easy to consume increase the popularity of these products (Garrett, 2002).

Fresh-cut products are generally produced as a result of processes such as peeling, turning into slices and cubes, cut into small pieces, packaging and storage of highquality fruits and vegetables (Ergun, 2006). The biggest problem with these products is a short shelf life. For this reason, marketing of fresh-cut products, especially fruits, is limited and most of the time, big supermarkets can prepare and market such products with their own means. Watermelon is at the forefront of fresh-cut products and melon, apple, pear, quince, strawberry, kiwi, pineapple etc. fruits are the other which follow these fresh-cut products. (Saftner et al., 2007).

Fruit firmness is an important criterion used in determining the harvest maturity in almost all fruits and vegetables, especially soft and stone fruits. As the maturity progresses, the fruit firmness decreases and in advanced maturity, the product softens well and becomes dandruff. In the last period of fruit development, fruit firmness decreases gradually due to the development of cells and intercellular spaces, pectin and hemicelluloses to be broken down and wall resistance decreases. If this decrease is stable and apparent especially after the ripening begins, the fruit firmness can be used as a good maturity criterion. In addition, the fruit firmness at the time of harvest is an important factor that determines the strength of the product after harvest (Bakoğlu, 2014). For the fruits and vegetables included in the fresh-cut process, the change in the fruit firmness progresses faster due to the deterioration of the product integrity (peeling, slicing, chopping, etc.) and the preservation process of the product is significantly shortened. It has been determined by various studies that the dipping solutions with protective properties that come into play at this point have positive effects on protecting the product quality (Özer 2002; Çalhan et al., 2012).

Işık and Kaynaş (2018), in their research that they tested the 7 and 14 days shelf life performance of the dipping solution of Natureseal, which was applied in 2% and 4% doses after slicing in the Pink Layd apple variety, they determined that 4% dose was successful for products stored for 90 days and 2% and 4% doses were successful for fruits stored for 150 days on the fruit and firmness of the preservative solution.

In a study conducted by Sabır et al. (2013), the evaluation of the 'Fuji' apple variety stored in the modified atmosphere (MAP) for 4 months as a freshly chopped product and the effects of preservation conditions before slicing on the slice quality and preservation period were examined. Apples harvested at the optimum maturity stage were divided into 2 groups, while the first group of samples were stored in Xtend MAP, the remaining fruits were kept open at 0 ° C and 90% relative humidity as a control for 4 months. Slicing of apples was carried out immediately after harvest and in the 2nd and 4th months of storage. Sliced apples were kept in 1% C and 90% proportional humidity for 21 days after being soaked in 1% ascorbic acid solution to prevent blackening. In samples taken at 7-day intervals, weight loss, total soluble solids (TSS), titratable acidity (TA), slice firmness, slice color, ascorbic acid amount and total phenol amount were analyzed. It has been determined that, especially with the prolongation of the storage period, it provides effective results in reducing weight loss and preserving the slice firmness in apples that are preserved in the MAP.

In the study conducted by Ergun et al. (2008) on the suitability of some cherry varieties for fresh cutting, it was investigated in 16 cherry varieties whether the cherry varieties could be evaluated as fresh-cut products, the fruits were cut lengthwise and divided into two parts. After the seeds were removed, the fruit pieces were placed in plastic containers that could be closed tightly. Plastic containers are kept at 4 °C for 10 days. After storage, loss of brightness, wrinkling, fruit surface collapse, cut surface collapse, blackening and rotting percentages were determined. Blackening and collapse on the cut surface in fruit pieces and loss of shine in the shell were found to be the most important factors limiting quality. The results showed that 9 cherry varieties used in the research can be evaluated as fresh-cut products.

In fresh-cut fruits and vegetables, enzymatic blackening can be controlled by reducing ambient temperature and oxygen in the environment. For this purpose, packaging techniques, different coating materials, gamma-ray applications or high-pressure preservation methods can be used in the modified atmosphere. Packaging techniques in a modified atmosphere with calcium or temperature applications also prevent negative changes in the texture that significantly affect the quality of these products (Güneş and Öz, 2014).

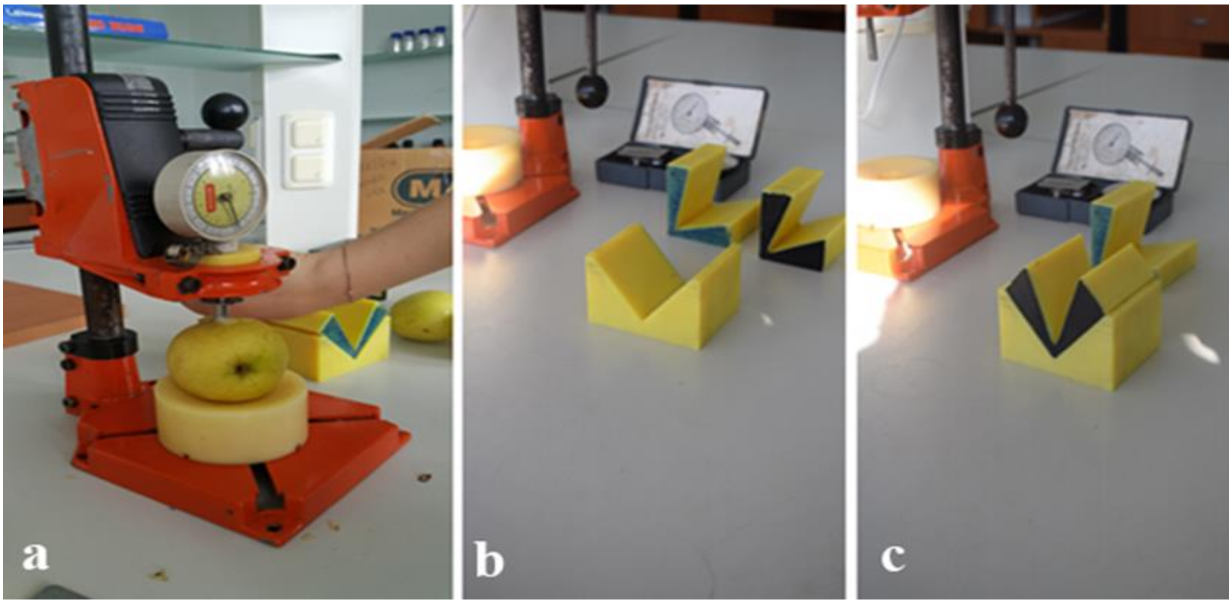

Figure 1: Spring arm printed penetrometer (a) and 45-60-90 V-blocks apparatus (b, c)

Materials and Methods

Materials

In this study, apple (Golden Delicious), pear (Deveci) and quince (Bread quince) fruits were used as plant materials. Fruits selected as materials for the study; choosed among the healthy fruits, which reflect the variety characteristics, not damaged,. Apples were obtained from 12 years old, pears 9 years old and quinces 13 years old from the producer orchards in Çanakkale province. Fruit harvest periods were 22nd September in apples, 25th October in pears and 21st November in quince.

Fruit firmness measurements were made using an effegi type spring-loaded penetrometer mounted on a spring-loaded lever press and a diameter of 8 mm, and the measured values are expressed in Kg (Figure 1a.).

Blocks apparatuses with angles of 45°, 60°, 90° are used to determine the fruit firmness of the fruits sliced at different angles (8,6 and 4 slices). (Figure 1b., Figure 1c. and Figure 2g.). V-blocks assembly is a device designed to measure in sliced fruits at different cutting angles (45°: 8 slices, 60°: 6 slices, 90°: 4 slices). V-blocks of 45° or 60° is used by sitting on 90° V-blocks. The application to the Turkish patent institute as of 2018 has been accepted for the designed V-blocks assembly and the patent evaluation process continues with the file number 2018/08403.

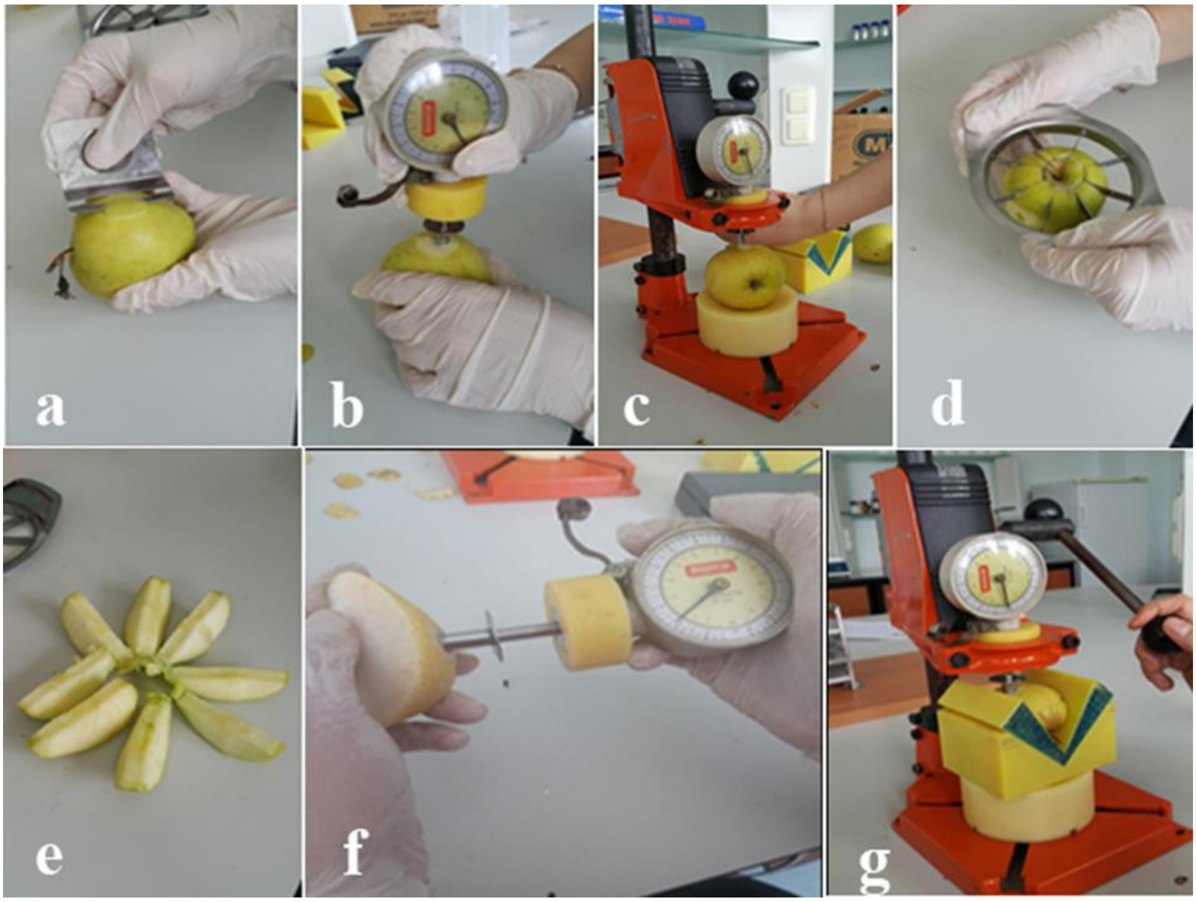

Figure 2. The sequence of procedures followed in the study: a: Peeling with a peeler, b: Hand firmness measurement in non-sliced fruit, c: Measurement with a spring-arm printed penetrometer in non-sliced fruit, d - e: Slicing of the fruit, f: Firmness measurement of sliced fruit, g: Firmness measurement of the sliced fruit with spring-loaded penetrometer and V-blocks device

Methods

In the research carried out in ÇOMÜ Faculty of Agriculture, Department of Horticulture in 2018; fruit firmness measurement for each type of fruit taken in the trial was carried out in 4 different methods by hand in the sliced fruit, by the spring-loaded arm imprinted device in the non-sliced fruit, by hand in the sliced fruit, by using the spring-arm printed device and V-blocks in the sliced fruit. 3 replicates were measured in 7 fruits for 4 different firmness measurement methods called product group.

The sequence of procedures followed in the study is as follows:

- Before measuring, the fruit surface was peeled about 1 cm² with the peeler at the measuring point (Figure 2a.).
- Firmness measurement has been done without using any device in the fruit that is not intact (non-sliced) (Figure 2b.).
- Firmness measurement has been done with a penetrometer mounted on spring arm pressure device in fruit that has not been intact (non-sliced) (Figure 2c.).
- Fruit is sliced (Figure 2d and 2e.).
- Sliced fruit was held in hand and the firmness was measured with the help of a penetrometer (Figure 2f.).
- Sliced fruit was measured using a V-blocks with the help of a penetrometer adapted to the spring-loaded arm.

In the product groups, application and repetition subject to the trial, the measurements of fruit firmness were taken as Kg by repeating the measurements in the order given above. The obtained firmness values were converted to averages on the basis of product and application, and the stability of the values obtained from the four different fruit firmness measurement methods was compared by calculating the standard deviation between the measurement values taken on the basis of repetition. In addition to these comparisons, it was tried to emphasize the stability of measurement methods whose measurement value averages were converted to box-plot charts.

Table 1. Fruit frimness avarages (Kg) and standart deviations in the study.

V-Bloks Angel (°)	Measurement.Method	Fruit Number	Apple		Pear		Quince	
			Firmness Avarage (Kg)	Standart Deviation	Firmness Avarage (Kg)	Standart Deviation	Firmness Avarage (Kg)	Standart Deviation
-	nS-F-HM	1	2.05	0.05	3.70	0.10	6.20	0.10
-	nS-F-HM	2	2.15	0.05	4.05	0.05	6.60	0.10
-	nS-F-HM	3	2.10	0.10	3.55	0.15	7.05	0.15
-	nS-F-HM	4	2.00	0.00	4.20	0.00	7.30	0.20
-	nS-F-HM	5	2.00	0.10	4.60	0.10	7.40	0.20
-	nS-F-HM	6	1.95	0.05	3.65	0.25	5.80	0.10
-	nS-F-HM	7	2.00	0.00	3.80	0.10	6.65	0.25
-	nS-F-HM	1	2.15	0.05	3.70	0.10	5.70	0.20
-	nS-F-HM	2	2.25	0.05	3.60	0.20	6.55	0.15
-	nS-F-HM	3	2.35	0.05	4.35	0.25	6.70	0.10
-	nS-F-HM	4	2.40	0.10	3.90	0.10	7.20	0.10
-	nS-F-HM	5	2.45	0.25	4.15	0.05	6.55	0.15
-	nS-F-HM	6	2.55	0.05	4.20	0.00	5.90	0.10
-	nS-F-HM	7	2.45	0.05	3.80	0.10	6.20	0.00
-	nS-F-HM	1	2.65	0.05	3.60	0.10	6.95	0.05
-	nS-F-HM	2	2.95	0.05	3.15	0.05	6.60	0.20
-	nS-F-HM	3	2.65	0.05	4.00	0.10	6.40	0.20
-	nS-F-HM	4	2.60	0.20	3.95	0.25	7.05	0.05
-	nS-F-HM	5	3.05	0.05	3.40	0.30	6.35	0.15
-	nS-F-HM	6	2.55	0.25	3.50	0.30	5.65	0.25
-	nS-F-HM	7	2.15	0.05	3.25	0.15	7.60	0.30
-	nS-F-MM	1	2.50	0.00	4.15	0.25	6.50	0.00
-	nS-F-MM	2	2.90	0.10	4.05	0.05	6.40	0.10
-	nS-F-MM	3	2.95	0.05	4.10	0.10	6.35	0.15
-	nS-F-MM	4	2.95	0.05	4.10	0.10	5.70	0.10
-	nS-F-MM	5	2.20	0.00	3.90	0.10	6.95	0.15
-	nS-F-MM	6	2.75	0.15	3.60	0.10	6.70	0.20
-	nS-F-MM	7	1.70	0.10	2.80	0.10	7.00	0.10
-	nS-F-MM	1	2.00	0.00	3.95	0.15	6.30	0.20
-	nS-F-MM	2	2.40	0.10	3.90	0.00	6.25	0.15
-	nS-F-MM	3	2.25	0.15	3.10	0.10	6.50	0.00
-	nS-F-MM	4	2.75	0.15	3.65	0.25	6.40	0.10
-	nS-F-MM	5	2.20	0.20	4.25	0.15	6.00	0.00
-	nS-F-MM	6	2.90	0.00	4.00	0.40	5.45	0.05
-	nS-F-MM	7	2.65	0.15	3.95	0.05	6.35	0.15
-	nS-F-MM	1	3.05	0.05	3.00	0.20	5.65	0.25
-	nS-F-MM	2	2.50	0.10	3.10	0.10	7.75	0.25
-	nS-F-MM	3	3.30	0.10	3.10	0.10	6.55	0.45
-	nS-F-MM	4	3.40	0.10	3.45	0.15	6.90	0.30
-	nS-F-MM	5	3.65	0.05	4.40	0.20	5.85	0.55
-	nS-F-MM	6	2.80	0.10	4.15	0.15	7.10	0.20
-	nS-F-MM	7	2.65	0.05	4.10	0.10	7.05	0.15
45	S-F-HM	1	2.13	0.05	4.33	0.09	5.33	0.24
45	S-F-HM	2	3.27	0.21	4.10	0.08	4.83	0.29
45	S-F-HM	3	2.77	0.88	4.03	0.12	4.53	0.45
45	S-F-HM	4	3.10	0.14	4.17	0.09	5.30	0.29
45	S-F-HM	5	1.40	0.16	3.03	0.09	6.87	0.12
45	S-F-HM	6	2.10	0.08	3.13	0.21	6.17	0.09
45	S-F-HM	7	1.67	0.12	2.20	0.14	6.47	0.25
60	S-F-HM	1	2.37	0.21	3.20	0.08	4.53	0.68
60	S-F-HM	2	2.03	0.05	3.30	0.16	4.20	0.24
60	S-F-HM	3	2.03	0.12	2.93	0.12	5.43	0.09
60	S-F-HM	4	1.73	0.46	3.43	0.29	4.77	0.34
60	S-F-HM	5	2.10	0.22	4.07	0.17	5.27	0.26
60	S-F-HM	6	2.77	0.21	4.10	0.16	5.23	0.12
60	S-F-HM	7	3.40	0.33	3.40	0.33	6.10	0.08
90	S-F-HM	1	2.45	0.05	2.87	0.12	4.50	0.37
90	S-F-HM	2	2.25	0.05	2.40	0.50	6.60	0.37
90	S-F-HM	3	2.50	0.00	2.87	0.12	6.23	0.21
90	S-F-HM	4	2.70	0.10	3.20	0.16	6.77	0.26
90	S-F-HM	5	1.55	0.05	4.00	0.08	5.97	0.25
90	S-F-HM	6	2.15	0.15	3.97	0.05	6.53	0.29
90	S-F-HM	7	2.25	0.15	3.87	0.12	6.43	0.25

Table 1 Continued

V-Bloks Angel (°)	Measurement.Method	Fruit Number	Apple		Pear		Quince	
			Firmness Avarage (Kg)	Standart Deviation	Firmness Avarage (Kg)	Standart Deviation	Firmness Avarage (Kg)	Standart Deviation
45	S-F-Vblocks M	1	2.37	0.09	4.87	0.12	6.33	0.17
45	S-F-Vblocks M	2	2.30	0.08	3.90	0.16	6.13	0.25
45	S-F-Vblocks M	3	3.00	0.08	4.10	0.08	6.03	0.17
45	S-F-Vblocks M	4	2.50	0.08	4.13	0.12	6.23	0.21
45	S-F-Vblocks M	5	2.00	0.08	3.97	0.05	6.37	0.12
45	S-F-Vblocks M	6	1.87	0.09	3.43	0.17	6.63	0.25
45	S-F-Vblocks M	7	1.90	0.08	2.70	0.14	6.77	0.21
60	S-F-Vblocks M	1	2.87	0.09	3.40	0.14	6.40	0.14
60	S-F-Vblocks M	2	2.30	0.14	3.80	0.08	6.23	0.21
60	S-F-Vblocks M	3	2.37	0.12	3.27	0.12	6.17	0.24
60	S-F-Vblocks M	4	2.87	0.09	3.87	0.17	5.53	0.12
60	S-F-Vblocks M	5	2.53	0.09	4.33	0.09	6.03	0.17
60	S-F-Vblocks M	6	2.67	0.09	5.03	0.12	6.50	0.22
60	S-F-Vblocks M	7	2.53	0.09	3.90	0.16	6.23	0.17
90	S-F-Vblocks M	1	2.95	0.05	3.17	0.17	6.27	0.25
90	S-F-Vblocks M	2	3.75	0.05	3.60	0.16	7.17	0.21
90	S-F-Vblocks M	3	2.55	0.05	2.97	0.09	7.17	0.12
90	S-F-Vblocks M	4	2.55	0.05	3.87	0.12	6.83	0.21
90	S-F-Vblocks M	5	2.85	0.05	4.37	0.09	6.73	0.17
90	S-F-Vblocks M	6	1.85	0.05	4.27	0.09	6.90	0.16
90	S-F-Vblocks M	7	2.00	0.00	4.10	0.08	6.97	0.21

nS-F-HM: non-sliced fruit hand measurement
nS-F-MM: non-sliced fruit spring-loaded sleeve penetrometer (Machine) measurement
S-F-HM: sliced fruit hand measurement
S-F-Vblocks: sliced fruit Vbloks measurement.

Results and Discussion

Values taken from the firmness measurements made within the scope of fruit type, method and repetition are given in Table 1. In addition, the mean firmness values and standard deviation values of the repeats were calculated. To evaluate the obtained data on a product basis:

Fruit firmness measurements at apple:

In apples, the set values in the fruits obtained in the fruits with intact integrity vary between 1.90 - 3.10 Kg, while the measurements made with spring-loaded penetrometer remained in the range of 1.60 - 3.70 Kg. While the fruit firmness varies between 1.20 - 3.80 Kg in hand measurements after slicing the fruit, the measurement values taken with the V-blocks device have been found in the range of 1.80 - 3.80 Kg. Considering the standard deviations indicated by the measurement values, it was observed that the standard deviation values of the measurements made in the non-sliced fruits remained in the range of 0.00 - 0.25, while it remained in the range of 0.00 - 0.20 in the measurements made with a penetrometer. While the standard deviation in the firmness measurement values obtained after slicing in fruit varies between 0.00 - 0.88, the deviation value remained between 0.00 - 0.14 in the measurements made using the V-blocks assembly.

The changes in the average fruit firmness obtained in the measurements made for the apple in the study according to the measurement method are summarized in Figure 3, the measurement averages and standard deviation values are summarized in Figure 4.

As can be seen in Figure 3 in the standard deviation values taken in fruit firmness, the low standard deviation value in the hand, in spring-loaded penetrometer and V-blocks device means that the error in the measurements made on the basis of repetition is low. The standard deviation increase observed in the firmness measurements made in sliced fruits means that more errors are made during the measurement.

In the study, the mean values obtained from four different methods used in the measurement of fruit firmness are summarized in Figure 4 for apples. While the parallelism of the values taken with the spring-loaded lever-pressed penetrometer and the V-blocks assembly is clearly seen, the similarities on average on the basis of the measurements made by hand in non-sliced and sliced fruits draw attention.

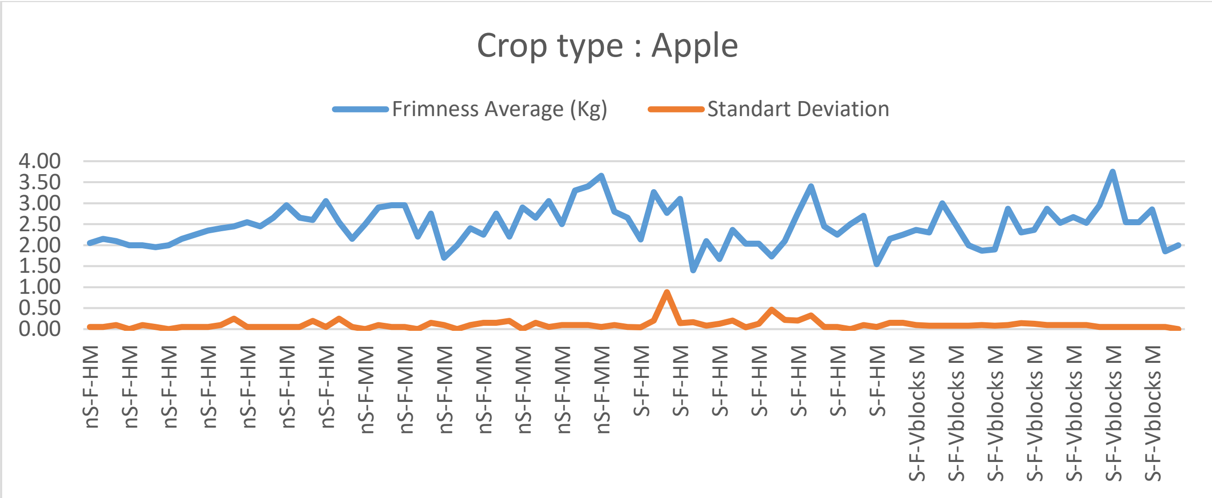

Figure 3. Average of apple firmness (Kg) and standard deviation values in apple

nS-F-HM: non-sliced fruit hand measurement
nS-F-MM: non-sliced fruit spring-loaded sleeve penetrometer (Machine) measurement
S-F-HM: sliced fruit hand measurement
S-F-Vblocks: sliced fruit Vbloks measurement.

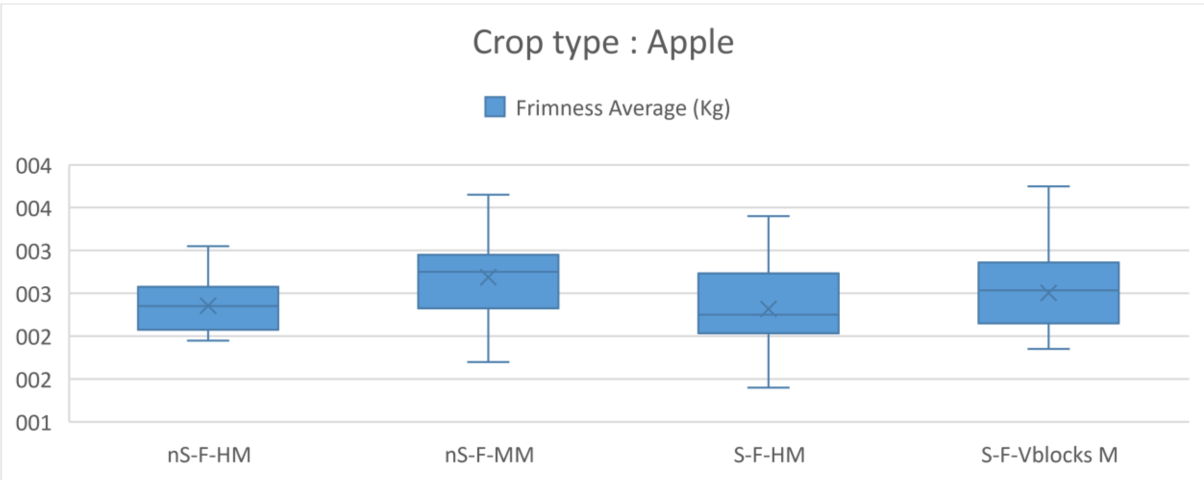

Figure 4. Fruit firmness (Kg) values according to measurement methods in apple.

Fruit firmness measurements in pear:

When we look at the results obtained from the penetrometric measurements made by the classical method in the non-sliced pear fruits, it is seen that the firmness values vary between 3.10 - 4.70 Kg, and the measurements made with the spring-arm printed penetrometer range between 2.70 - 4.60 Kg. The fruit firmness values obtained after slicing the fruit are in the range of 2.00 -4.40 Kg in the measurements made, while the measurements made by using the V-blocks assembly are between 2.50 - 5.00 Kg. If the standard deviations on the basis of the measurement method are examined, If the standard deviations on the basis of the measurement method are examined, it is determined that the standard deviations of the measured values obtained in the fruit whose intact integrity is in the range of 0.00 - 0.30, and the standard deviations of the spring-loaded penetrometer assembly vary between 0.05 and 0.40. The standard deviation value in the hardness measurements made after slicing the fruit ranged from 0.05 to 0.50 for hand measurements, and from 0.05 to 0.17 for measurements made using the V-wedge assembly (Table 1).

The fruit firmness averages and the standard deviation values shown by the four different measurement methods are summarized in Figure 5. Similar standard deviation fluctuations occur in hand and spring-arm printed penetrometry in unlicensed fruit, the fluctuation intensity increases somewhat in hand measurements after the fruit is sliced and the fluctuation decreases significantly in measurements made in the V-blocks assembly can be monitored from the standard deviation series in Figure 5.

The variations of the firmness value averages obtained according to the measurement methods show a balanced distribution in the sliced fruit, except for the manual measurements. In particular, it is observed that the firmness value shows a variation in the tendency that decreases the average in the fruit firmness measurements obtained after slicing the fruit (Figure 6). As can be seen from the standard deviation graph (Figure 5), the measurements made with non-sliced fruit and the measurements made with the V-blocks assembly in the sliced fruit gave more stable averages.

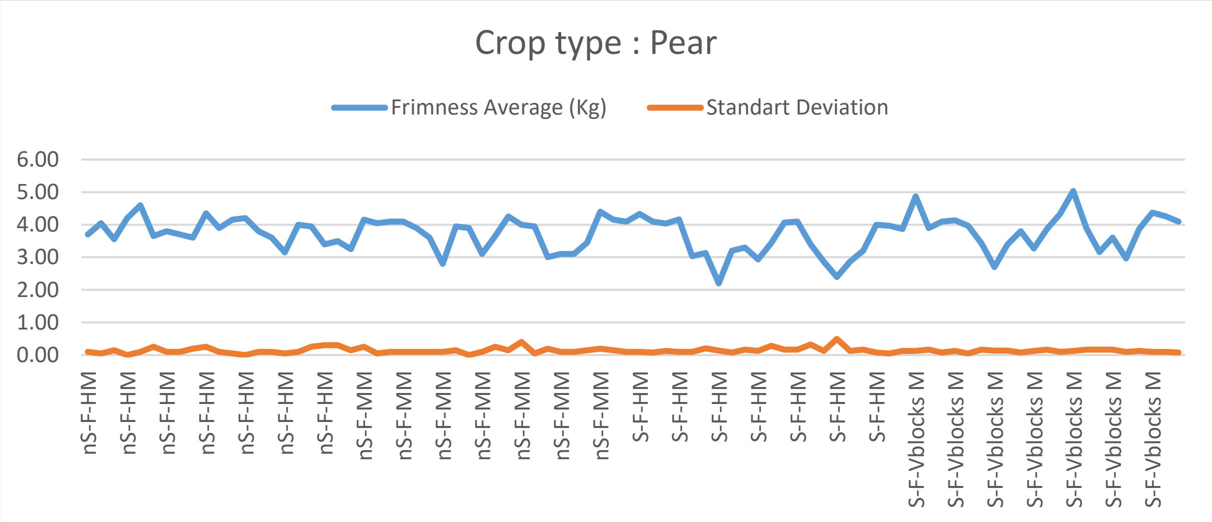

Figure 5. Fruit firmness (Kg) averages and standard deviation values in pear.

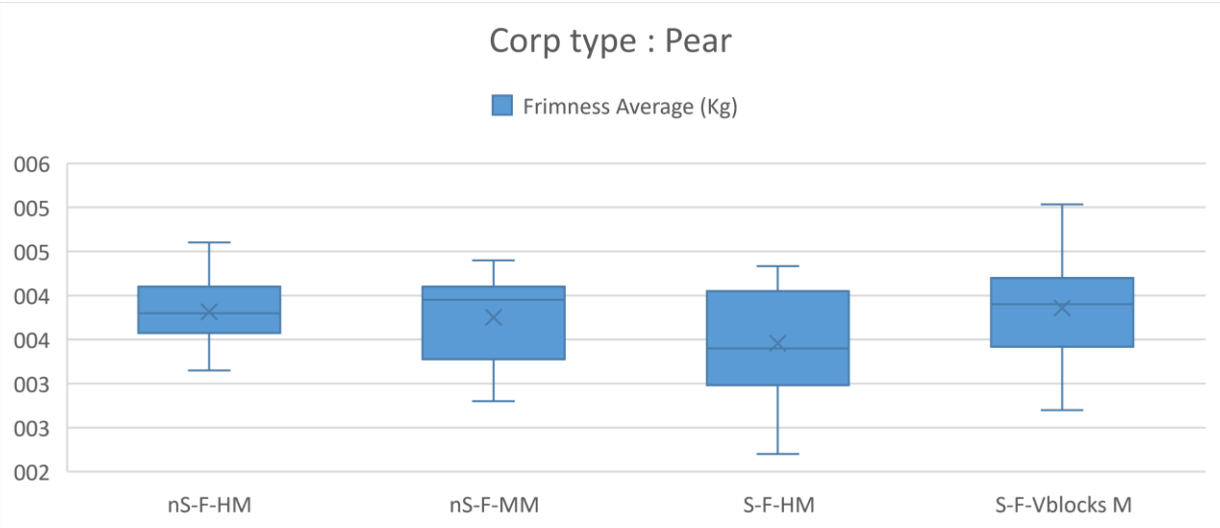

Figure 6. Fruit firmness (Kg) values according to measurement methods in pear.

Fruit firmness measurements in quince:

While the value of fruit firmness measurements made in unqualified quince fruits was in the range of 5.40 - 7.60 Kg, this value varied in the range of 5.30 - 7.90 kg in the measurements made with a spring-loaded penetrometer. Measurements obtained after slicing the fruit showed that the firmness value was in the range of 4.10 - 7.10 Kg., when the measurement took place in the V-blocks assembly, the change interval of the firmness value was found between 5.50 - 7.40 Kg. Considering the standard deviations shown by the firmness values taken with different methods; It was observed between 0.05 and 0.30 in the firmness measurements obtained before slicing the fruit. Again, before the slicing process, the spring arm printed penetrometer measures were between 0,00 - 0,55, and after slicing the measures were between 0,08 - 0,68. And again after slicing, it is seen that the measurements made using the V-blocks assembly are between 0.08 - 0.25 (Table 1.).

Average firmness values obtained for quince in fruit firmness measurements and standard deviation rates between the averages are shown in Figure 7.

Similar to the firmness measurement results obtained from apple and pear fruits, it can be observed in the standard deviation series in the graph in Figure 7, where the most fluctuation in terms of standard deviation in the quince occurs in the measurements performed after the fruit integrity is impaired.

Significant differences are observed in the method of fruit firmness for quince (Figure 8). Especially, the fact that the values obtained in the firmness measurements (S-F-HM series) obtained after slicing the fruit are in a wide variation range is due to errors made during the measurement. The variation in the firmness measurements with the V-blocks assembly remained in a much narrower range, so the standard deviation values were also in a relatively low range.

Quince is a fruit with higher fruit firmness than other products. If it is noted in Figure 7 and Figure 8, the firmness measurements taken from the spring-loaded penetrometer and V-blocks device showed much less variation on average basis than other measurement methods, and standard deviation values varied in a narrow range. As the fruit-specific firmness value increases, the error rate increases for manual fruit firmness measurement methods.

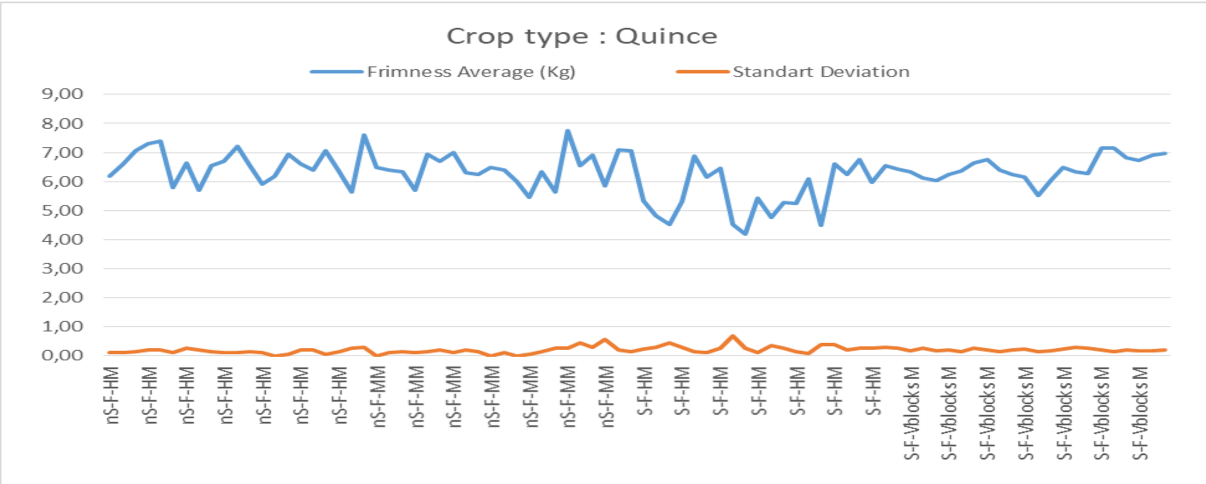

Figure 7. Average fruit firmness (Kg) in quince and standard deviation values

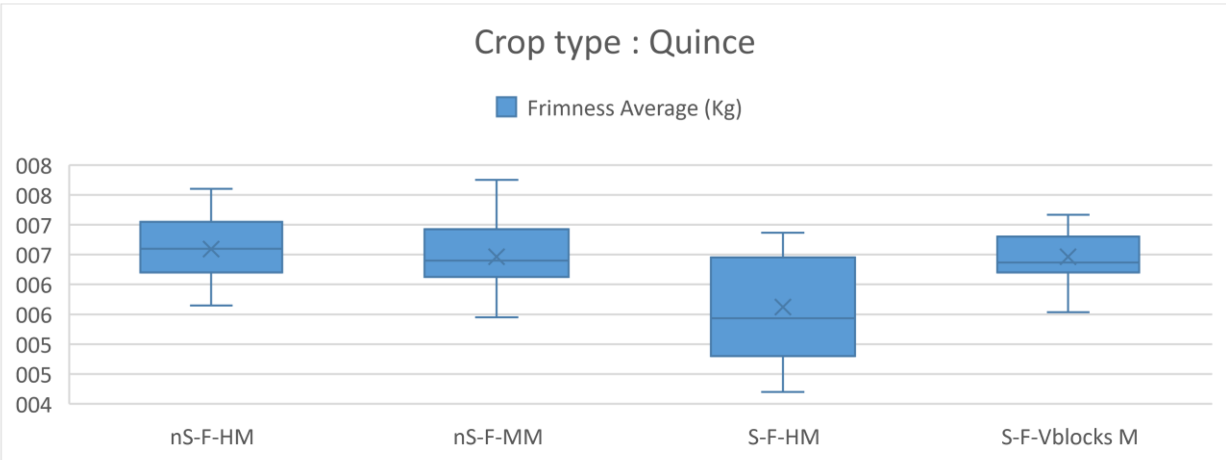

Figure 8. Fruit firmness (Kg) values according to the measurement methods in quince.

Conclusion

In the study, the success of the newly developed V-blocks assembly in the measurement of the fruit firmness of the new fruit type (apple, pear, quince) was obtained by considering the variations of the firmness values obtained by four different methods and the deviation of the firmness values from the mean.

The standard method for measuring the fruit firmness is the peeling of the product intact (non-sliced) fruit or some vegetables (approx. 1 cm^2 at the point of firmness measurement) by applying the force perpendicularly to the product surface by holding the fruit in a hand or by placing it on hard ground with the penetrometer measuring arm. The force (in N or Kg) applied to the measuring tip to enter the fruit is read from the penetrometer indicator as N or Kg. When the product is sliced and its integrity is broken, it will be necessary to measure the firmness of the product slices. This situation causes erroneous measurement values due to loss of strength and lack of support during measurement.

For fruit and vegetables were taken into the fresh-cut process, the change in fruit firmness progresses faster due to the deterioration of the product integrity (peeling, slicing, chopping, etc.) and the preservation process of the product is shortened significantly. It has been determined by various studies that the dipping solutions with protective properties that come into play at this point have positive effects on protecting the product quality. In fresh-cut product processing technology, the solutions used after the semi-finished product are dipping solutions used to slow down quality losses in the product. These solutions have been developed commercially by many companies and organizations and are still working on them. Fruit firmness is an indispensable quality criterion in the investigation of the positive or negative effects of new preservative solutions that are currently used and will be developed and put on the market. It is an important issue for researchers that this quality criterion can be measured accurately in sliced fruit.

As can be understood from the research findings, the most stable results in terms of standard deviation values, especially after the slicing phase of the fruit, were obtained from the measurements in which the V-blocks device was used. In the fruits divided into 8, 6 or 4 slices, the fact that the fruit cutting surface received support from the angled surfaces of the V-wedge caused the standard deviation and variation in the measurement values to be low. In addition, the fact that the penetrometer measuring arm entered the fruit tissues at an angle of 90° was also effective on these values.

After the fruit integrity is deteriorated (slicing, chopping, cutting into pieces), insufficient support during the firmness measurement of the fruit slice by hand and the penetrometer measuring arm is not pressed to the fruit at an angle of 90° or breaking the fruit slice due to excessive force are among the main reasons why the correct measurement cannot be made.

Another point that attracts attention in the research results is that as the firmness value of the product measured in the fruit firmness increases, the stability of the results obtained from the V-blocks device and spring-loaded penetrometer device does not change. As the force required to measure the fruit firmness increases, the error rate in other methods increases, causing variation and standard deviation rates in the average firmness.

References

Bakoğlu. N. 2014. Taze Kesilmiş (Fresh-Cut) Ürünlerde Kaliteyi Etkileyen Faktörler. VI. Bahçe Ürünlerinde Muhafaza Ve Pazarlama Sempozyumu 22-25 Eylül 2014 – Bursa.

Çalhan, Ö., Eren, İ., Onursal, C. E., Güneyli, A. 2012. Granny Smith Elma Çeşidin Dinamik Kontrollü Atmosferde (DKA) Depolanması. V. Bahçe Ürünlerinde Muhafaza ve Pazarlama Sempozyumu Eylül 2012, İzmir, 18-21.

Ergun, M., Ergun, N., Sütyemez, M. 2008. Bazı Kiraz Çeşitlerinin Taze Kesme işlemine Uygunluğu. Fen ve Mühendislik Dergisi, 11(2), s.112-120.

Ergun, M. 2006. Fresh-cut Physiology and Factors Contributing to the Quality of Fresh-cut Produce. KSÜ, Fen ve Mühendislik Dergisi, 9(1): 164-169.

Garrett, E.H. 2002. Fresh-cut produce: tracks and trends. (Fresh-cut Fruits and Vegetables: Science, Technology, and Market, Boca Raton, FL, ABD: Ed. Laminkara, O. 1-10.

Güneş, N., Öz, T. 2014. Taze Kesilmiş Meyve ve Sebzelerin Muhafaza Süresi ve Raf Ömrü Üzerinde Koruyucu Bazı Uygulamaların Etkinliği. VI. Bahçe Ürünlerinde Muhafaza ve Pazarlama Sempozyumu. 22-25 Eylül 2014.

Işık, M., Kaynaş, K. 2018. Soğuk Depolama Sonrası Taze Doğranmış Pink Lady Elma Meyvelerinde Bazı Uygulamaların Tüketici Koşullarında Kaliteye Etkileri. ÇOMÜ Ziraat Fakültesi Dergisi, 6: 9-17.

Özer, M. H. 2002. Elma Çeşidinin Kontrollü Atmosferde (KA) Muhafazası. Uludağ. Üniv. Ziraat Fakültesi Dergisi, (2002) 16(2): 189-202.

Sabır, F., Yiğit, F., Taşkın, S. 2013. Fuji Elma Çeşidinde Salisilik Asit Uygulamalarının Soğukta Depolama Süresince Kaliteye Olan Etkileri. Alatarım 2013, 12 (1): 19-25.

Saftner, R., Lou, Y., McEvoy, J., Abbot, J.A., Vinyard, B. 2007. Quality Characteristics of Fresh-cut Watermelon Slices from Non-Treated and 1- Methylcyclopropene –and/or Ethylene Treated Whole Fruit. Postharvest Biology and Technology, 44: 79-85.