Turkish Journal of Agriculture and Forestry

Volume 22 | Number 4 Article 15

1-1-1998

Some Factors Affecting on Determination and Measurement ofTomato Firmness

Ali BATU

Follow this and additional works at: https://journals.tubitak.gov.tr/agriculture

Part of the Agriculture Commons, and the Forest Sciences Commons

Recommended Citation

BATU, Ali (1998) "Some Factors Affecting on Determination and Measurement ofTomato Firmness," *Turkish Journal of Agriculture and Forestry*: Vol. 22: No. 4, Article 15. Available at: https://journals.tubitak.gov.tr/agriculture/vol22/iss4/15

This Article is brought to you for free and open access by TÜBİTAK Academic Journals. It has been accepted for inclusion in Turkish Journal of Agriculture and Forestry by an authorized editor of TÜBİTAK Academic Journals. For more information, please contact academic.publications@tubitak.gov.tr.

Tr. J. of Agriculture and Forestry
22 (1998) 411-418
© TÜBİTAK

Some Factors Affecting on Determination and Measurement of Tomato Firmness

Ali BATU
Gaziosmanpaşa University, Agriculture Faculty, Food Engineering Depratment, 60100, Tokat-TURKEY

Received: 01.10.1996

Abstract: Firmness is one of the most important factor for determination of tomatoes quality. Distructive measurement of tomato firmness is one of the evaluation methods of fruit firmness. The Universal Instron is most common used machine for measurement of most adeqequate fruit firmness. During destructive measurement of firmness considedation of force or deformation values as a firmness of fruits could give incorrect result and taking epicarp strength over deformation values is more accurate to concern the firmness of tomato. Two of possible minimum firmness limits were suggested for tomato fruits at the point of retail marketing or using at home. All 100% marketable fruits should have firmness values above 1.45 N mm^{-1} but the Instron values of the tomato mainly consuming stage at home, should have higher than the 1.28 N mm^{-1}. The firmness of tomatoes is closely assosiated with acceptability levels of the fruits. Subjective evaluation scores based on finger feel highly and positively correlated 0.96 and 0.98 with epicarp strength and firmness values, respectively. A negative and highly significant correlation (-0.97) exists between deformation values of subjective evaluatoin scores of Liberto variety, but this correlation slightly lower for Criterium and that was -0.89. Cuting the skin of mature green tomatoes did not affect on firmness but removing the skin highly effect on it. Both cutting and removing of the skin affected measurement of the firmness of tomatoes harvested at pink stage of maturity.

Domates Sertliğinin Belirlenmesi Üzerine Etkili Bazı Faktörler

Özet: Domates kalitesinin belirlenmesinde sertlik en önemli faktörlerden birisidir. Ürünün sertlik değerlerinin parçalanarak belirlenmesi en yaygın olarak kullanılan yöntemlerinden birisidir. İnstron ise sertlik ölçümünde yaygın olarak kullanılan çok hassas ve evrensel bir alettir. Bu aletin kullanımı ile kuvvet/deformasyon eğrisi elde edilmektedir. Eğer meyvenin sertlik değeri ürünün parçalanarak belirlenmesi durumunda İnstron aleti ile elde edilen sadece kuvvet veya deformasyon değerinin sertlik değeri olarak algılanması ve belirtilmesi doğru olmayıp kuvvetin (N) deformasyon (mm) değerine oranı (N/mm) olarak verilmesinde doğru sonucu vermektedir. Hiç yumuşama belirtisi olmayan %100 sertlikte olan domatesin pazarlanabilmesi bakımından 6 mm düz uçlu delği ucunun kullanımı ile İnstron sertlik değerinin 1.45 Nmm^{-1} nin üzerinde olması gerekmektedir. Kısmen yumuşamış fakat mutfakta rahatlıkla kullanılabilinir sertlikte olan domatesin en düşük İnstron değeri ise 1.28 Nmm^{-1} olarak belirlenmiştir. Parmak ile duyusal sertlik değerlendirmesi ile İnstron verilerinden elde edilen yırtılma kuvveti arasında 0.96 ve sertlik değerleri ise 0.98 gibi yüksek korelasyon olduğu saptanmıştır. Korelasyon katsayı deformasyon değeri için ise (-0.89) ile (-0.97) olduğu saptanmıştır. Yeşil domatesin kabuğunun kesilmesi sertlik değeri üzerine önemli bir etki yapmazken kabuğun soyulması ise sertlik değerini önemli derecede azaltılmıştır. Pembe olum aşamasında ise hem kabuğun kesilmesi ve hemde soyulması sertlik önemli derecede azaltılmıştır.

Introduction

There is increasing consumer concern about the eating quality of tomatoes. After harvest, ripening continues and tomatoes can became overripe very rapidly. This can result in loss of quality and resticted shelf life (1). The textural quality of tomatoes is influenced by flesh firmness, the ratio between pericarp and locular tissue, and skin toughness. Changes in firmness were highly correlated with surface apperance charecteristics of tomatoes (2) which related to colour, shape and sense of fell to firmness at time purchase or afterwards slicing and eating fruits. The degree of fruit firmness, has been user as an indication of fruit quality (3). However, firmness may be the final index by which the consumer decides to purchase of tomatoes (4) using finger to test tomato firmness at the time of selection (5).

Fruit firmness can be determined in destructive and non-desructive methods. In the destructive method; the amount of force required to penetrate through to tomato flesh (skin and pericarp) and amounth of deformation values could be recorded. Onother way is to determine to force requred to deform the tissue by a certain distance or by determining the degree of deformation for a certain applied force (6). This was called disructive method.

Many kinds of machines have been developed which could measure firmness by destructive and non-destructive methods and they have been used for tomatoes for a long time. Destructive methods which have been used for tomatoes include pressure tester, Allo-Kramer Shear Press (5) and Instron Universal Testing machine (IUTM (Table 1) most common and more accurate one using for this purposes. Insruments for non-desructive determination of tomato firmness were Cornell Pressure Tester (7) Firme-o-meter (8; 9; 10) and IUTM (11).

A number of works have been involved in tomato fruit firmness measurements, and different insruments for measuring firmness have been illustrated in Table 1. There is a contradictory information about the results of firmness measurements in literature. It is difficult to compare data from one intrument to onother, or to relate these data to sensory wadgments (5). There are no satisfactory information on whether the measured firmness values of tomatoes were within the acceptable levels for consumers concern. Furthermore, the final units of expression of tomato firmness given were too various from one researcher to anotherone. Additionally, the unit of fruit firmness given as a force unit (N or kg) by many researchers for apples (1; 11; 24; 25), for pears (25; 26) and for mango (27).

The main objective of this study, therefore, were; firstly, to investigate the realible determination teqnique for firmness measurements of tomatoes. Secondly to determine the minimum level of acceptable firmness of tomato fruit cultivars, 'Liberto' and 'Criterium' at the time of picking and after storage, by evaluating objective tomato firmness and relate these objective measurements to subjective rating scale based on finger feel firmness. Finaly to investigate the skin effect on measurements of tomato firmness.

Material and Methods

In the first experiment, tomato fruits from 'Liberto' and 'Criterium' varieties of tomatoes at pink, ligt red and red stages of maturity were harvested from glasshouse of Silsoe Research İnstitute and then hold at 20°C. Ten fruits were seperated to the five firmness classes by finger feel firmness (100%, 80%, 60%, 40% and 20%). 100% firmness class was selected on the day of harvest, while those for the other classes were sorted out later on when

Table 1. Firmness Testers and their applications

Equipment	Application methods and experisson of the units	Literature
UC Fruit Firmness Tester	Fruit Firmness Tester Reading (1bs)	5
Shear Press	The force required to compress each fruit by 5 mm was observed	4
Firm-o-Meter	Comparison in mm under 1 kg load within 5 s or 3 s	8; 9; 10
Durameter	Durameter Values	12
Effigi Pressure Tessure	kg cm^{-2}	13
Instron Universal Testing Machine	Required force was recorded by compressing of fruits 5 mm with a flat ended probe	14
	Required force (N or kg) to depress the surface of tomato 5 mm with 5.7 cm diameter $probe^{-1}$	15
	Force recorded to penetrate 11 mm probe through 8 mm	16
	Deformation (mm) was recorded with 19 mm probe by	17
	loading 5 Newtons	18
	Required force and deformation was recorded from	19
	Force/deformation curve (N mm^{-1}) with 1 mm probe	20
	Required force and deformation was recorded from Force/deformation curve (N mm^{-1}) with 6 mm probe	21; 22

tomatoes reached to desirable texture of finger feel firmness. 100 fruits were used for this experiment. The results were expressed as percentages. Seperation was tested using a triangular test method. On a subjective basis only 100, 80 and 60% were considered acceptable for marketing. These judgement were based on a ten member of panel.

The five different acceptability (%) levels of tomatoes were;

100 : Just picked up at the pink or light red stage, very fresh and easily marketable

80 : Picked up at pink or light red maturation stage and stored for 2-3 days, but they remained very firm and there was no indication of softness by finger touching test. Easily marketable.

60 : Stored tomatoes, although they were slightly soft but their firmness were good enough for making salads and slicing. Marketable.

40 : Stored tomatoes. They were not good enough for making salads but could be used for cooking or Production of tomato paste. Unmarketable in the supermarket.

20 : Over ripe tomatoes more soft than 50%. They could be used for cooking or production of tomato paste. Unmarketable in the supermarket.

In the second experiment; only Criterium variety was used as in the first experiment. Three treatments (skinless, cut skin and normal) were carried out on the same tomatoes and on the equatorial line of fruits (Plate 1).

Skinless : 1 cm^2 area of tomatoes skin was cut to 2-3 mm depth then the skin was removed very carefully.

Cut skin : The skin was cut in the same way as the skinless but skin was left in place.

Normal : The skin was not cut and the fruit were left intact.

Desructive deformation tests was used by recorded force and deformation values from force/deformation curve to determine the minimum levels of acceptable firmness of tomatoe. This test was used (21) by applying a constant 50 N weight using with an Instron Universal Testing Machine, model 1122 were carried out. In the firmness measurements 6 mm diameter round stainless steel probe with a flat end was used and cross-head and

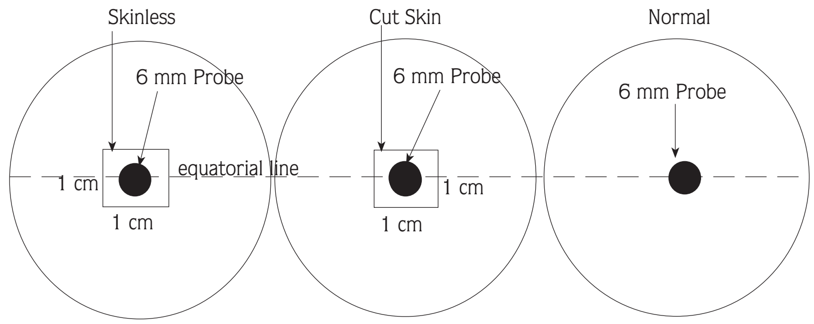

Plate 1. Application of firmness measurements on treated tomatoes

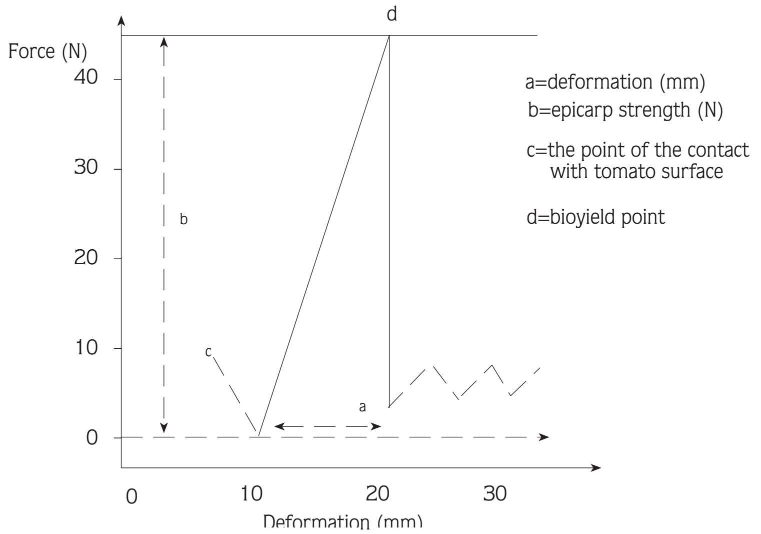

Figure 1. Typical force/deformation curve obtained during penetration of individual tomato

chart speed were 20 mm minute^{-1}. The amount of force (N) which was required to penetrate through the skin to the tomato flesh, and deformation (mm) values during penetration were recorded. Three textural characteristics were determined from the force/deformation curve in Figure 1. Epicarp strength was the (or force required to punch trough flesh of tomatoes) force (N) at the bioyield point. Deformation was the distance (mm) travelled by the probe from first contact with the tomato skin to the bioyield point. Firmness (N mm^{-1}) was defined as the average slope of the force/deformation curve (20).

Result and Discussion

Determination of Reliable Measurements of Tomato Firmness

As shown in Figure 2 and 3 the relation between epicarp strength (force) and acceptability levels or deformation and acceptability levels of 'Liberto' and 'Criterium' varieties were ilustrated. The results show that there was significant difference between varieties interms of epicarp strength and deformation values. Liberto had required higher force to penetrate through fruit skin and flesh, and it gave also higher deformation (figure 3) during this penetration time compared to Criterium ones. In comparison i.e. although both varieties had the approximately the same epicarp strength values with the fresly harvested tomatoes (100% acceptability level) and there was a slight decrease with epicarp strength of Liberto while epicarp strength of Criterium ones were decreasing rapidly with decreasing of acceptability levels of tomatoes. In contrast deformation increases at the marketable stages (100, 80 and 60% levels) of tomatoes. There was a rapid increase in the deformation values of Liberto and Criterium varieties after 60% and 40% acceptability levels respectively. Consequantly, Liberto is totaly different from Criterium interms of epicarp strength and deformation values. When they compared i.e. at 80% or 60% acceptability levels Liberto had significantly higher epicarp strength than Criterium one. Although both varieties had, approximately, the same finger feel firmness and they are

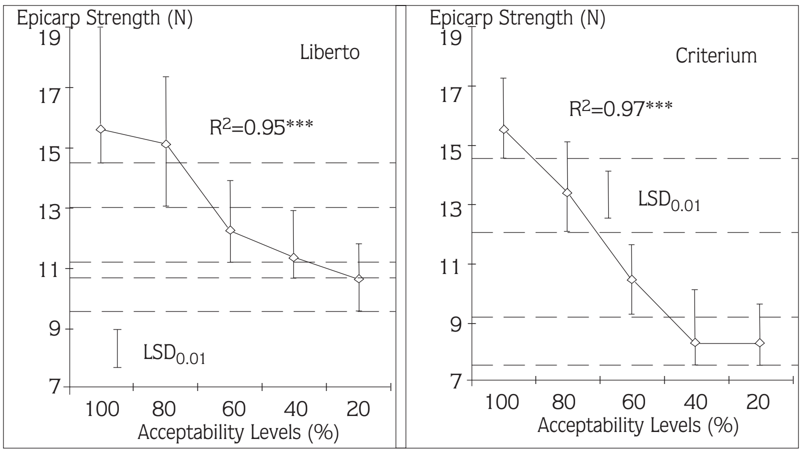

Figure 2. Relationship between epicarp strength values and acceptability levels of tomatoes

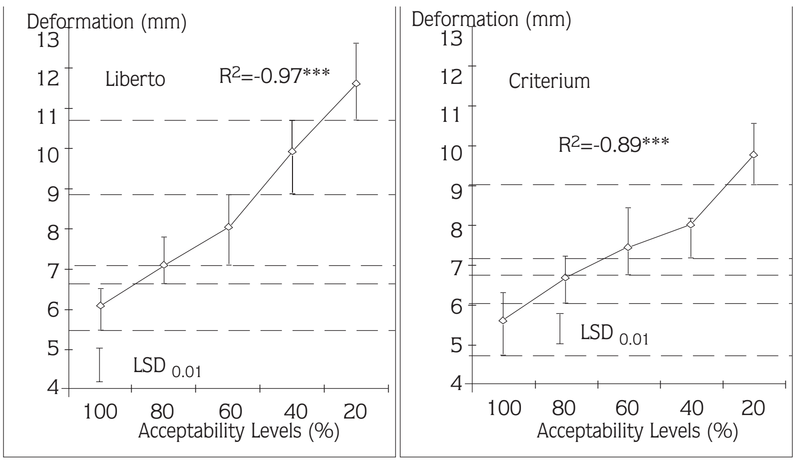

Figure 3. Relationship between deformation values and acceptability levels of tomatoes

supposed to be at the same firmness values if only epicarp strength values were concerned It. seems Liberto is more firmer than Criterium, furthermore when the deformation values were concerned. It seems Liberto is more softer than Criterium. Although there was a significant (p=0.05) difference on epicarp strength and deformation values (Figure 2 and 3) between tomato varieties, significant difference was not observed on firmness (epicarp strength over deformation) values between the same varieties (Figure 6).

More results are available in Figure 4 and 5 on relationship between the force, deformation and firmness values of some tomatoes. Those datas were chosen from in the field of more than 1000 measurements. First consideration was to keep the force values were aproximately the same in order to evaluate the effects of constant values of force or deformation on the variation of firmness values of tomatoes.

As can be from figure 4 there are six different treatments which epicarp strength (force) of the first three treatments (1, 2, 3) had approximately around 15 N and another three (a, b, c) of them had 17 N. But the deformation values of that first group (1, 2, 3) and socend group (a, b, c) occured variable not constant. As can be seen from figure 5 there were some treatments which their epicarp strength (force) values were varied but deformation values aproximately the same. So some of the fruits might have the same epicarp strength values and the same time they could have also various deformation values as in Figure 4. In this case their firmness values were occured to be conversely correlated with their deformation values. In comparison if the same force loaded on diffirent fruits which had lower deformation value that means this fruit is more firmer and if deformation value is higher, this fruit is more softer. If the epicarp strength (force) is various while the deformation values were the same, in this case firmness values were directly correlated with the epicarp strength and the less force requires that those fruits were more softer.

As a consequintly, deformation values can be concerned as a firmness for tomatoes when the application force was constant, or epicarp strength (force) also can be concerned as a firmness values of

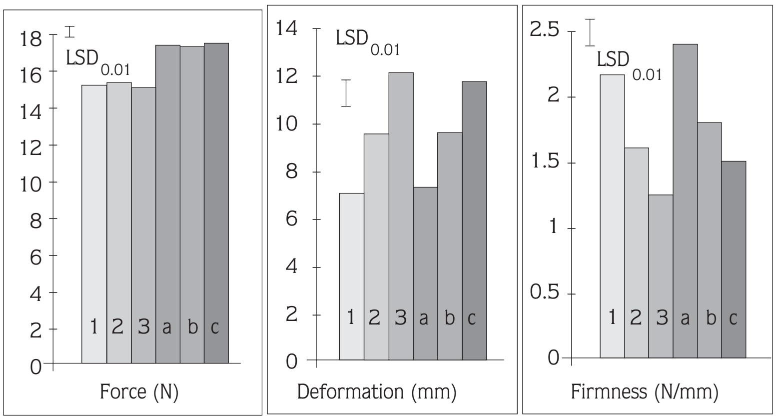

Figure 4. Changes on firmness values when the epicarp strength (force) was constant and deformation values was not constat.

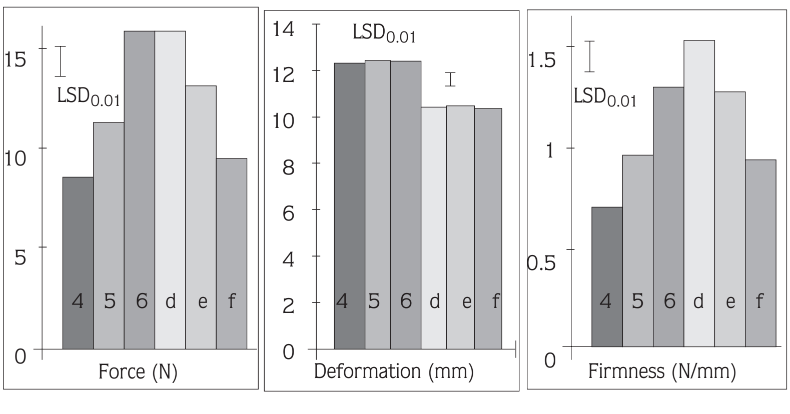

Figure 5. Changes on firmness values when the epicarp strength (force) was unconstat and the deformation values was not constant.

fruits when deformation values were kept as constant. This results confirm that during distructive firmness measurements, concerning of only force or deformation vlaues as a firmness of fruits, particularly for tomatoes, generally is not occurate. It is more accurate and important to take epicarp strength over deformation (N mm^{-1}) values for concerning of firmness assesment of tomatoes.

Determination of the Minimum acceptable firmness levels

The relationship between subjective firmness values which is very important for martketing, and objective firmness evaluation (acceptibility levels) of tomatoes was investigated. The minimum acceptable firmness values (or marketability levels) of tomatoes were determined by using a force/deformation test.

As expected firmness values of tomatoes decreased with decreasing of acceptability levels over the range of 100% (perfect) to 20% (overripe). There was a significant (p=0.05) decrease firmness values of both varieties of tomatoes (Figure 6). Similar result were seen for epicarp strength values (Figure 2).

There was a consistant decrease in firmness values of 'Liberto' between 100% and 40% acceptability levels. This decrease was between 100% and 80% acceptability levels for 'Criterium'. In both vareties, there was a higher varation between maximum and minimum firmness values at 100% and 80% acceptability levels. Those variation between maximum and minimum firmness values at 100% and 80% acceptability levels. Those variation levels were smaller in the 60%, 40% and 20% acceptability levels. According to the results of this research on the base of objective firmness evaluation (finger feel firmness) it was found that the minimum acceptable levels marketability scores of tomato firmness at which an individual tomato fruit could be acceptable for sale at reatil level is about 1.45 N mm^{-1} and 1.46 Nmm^{-1} for 'Liberto' and 'Criterium' varieties of tomatoes respectively. However, the firmness values of the tomatoes generally used at home is about 1.28 N mm^{-1}

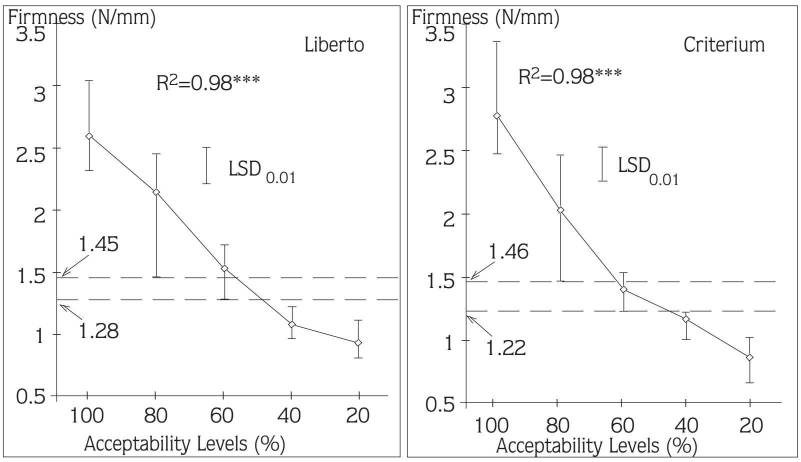

Figure 6. The relationship between measured firmness values and subjective market acceptability levels of tomatoes (cv's 'Liberto' and 'Criterium'). The vertical lines represent maximum and minimum values.

For Liberto, 1.45 Nmm^{-1}: very firm, 1.28 Nmm^{-1}: slightly soft but good enough for making salad
For Criterium, 1.46 Nmm^{-1}: very firm, 1.22 Nmm^{-1}: slightly soft but good enough for making salad

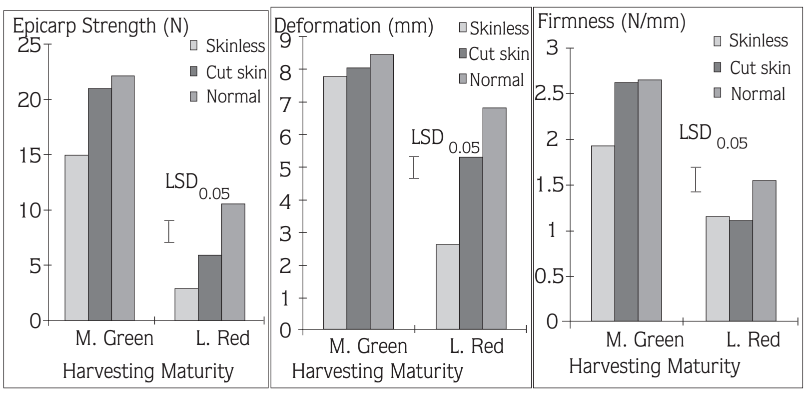

Figure 7. Epicarp strength, deformation and firmness values of light red and mature green tomatoes which were tested when either skinless, cut skin or normal (see plate 1)

and 1.22 N mm^{-1}, for tomatoes had 60% acceptability score for the Liberto and Criterium varieties, respectively. Those tomatoes could be also marketable even in supermarkets and they were capable to being sliced those kind of tomatoes in the supermarket and very difficult to slice or to use them for marking salads. If the firmness values of tomatoes above than the 1.28 N mm^{-1} (slightly soft) they could be used for making salad especially if their firmness is above 1.46 N mm^{-1} (very firm) those tomatoes easily marketable in the supermarket.

Skin Effect on Firmness Eveluation

In this experiment, the effect of the skin on destructive firmness measurement of texture by using force/deformation test was investigated. As would be expected it was found that removing or cutting the skin of tomatoes required a lower penetration force, in another word, epicarp strength values of those teratments were occured lower and resulted in lower deformation values compared with normal (intact) fruits for the both fruits picked at either mature green or at light red stages of maturity (Table 7). Although decreasing the required force for penetration of the probe through tomato flesh was not significant between cut skin and normal, it was significantly less between skinless and the other two treatments of green tomatoes. Difference was found that significant in the amount of force required between those three treatments on light red tomatoes. It was found that there was no significant difference on deformation values of green tomatoes, but it was significant for light red tomatoes.

It was found that there was no difference in measurement of firmness due to cutting the skin of mature green tomatoes (Figure 7). However, these differences were significant when the skin was removed. But this case was the reverse on light red tomatoes. There was no difference on flesh firmness between cut and removed skin (skinless) treatments. These results are in agreement with the studies of Kader et al (5) who reported that skin removal resulted in lower force values for fruit picked at various ripeness stages and a trend of firmness decreased with increasing ripness. They had pointed out that although removing the skin is recommended for textural measurements of for fruits such as apples, pears, etc. but it was not essential for tomatoes. This could be due to the thinness of tomato flesh and tomatoes are more juicy than apple, additionaly it is also more difficult to measure the firmness of tomatoes without skin.

Conclussion

If the firmness values of tomatoes evaluate by Universal Instron machine using 6 mm round and flat ended probe are above 1.28 N mm^{-1} they are suitable for making salad and even formarketing. If the firmness value is above 1.46 N mm^{-1} those tomatoes are definetely very firm and easily marketable in the supermarket. It is very obvious that there are significant differences in the texture measurement techniques between skinless and normal for either mature green or light red tomatoes. It could be interpreted that these differences of firmness could be due to properties of the skin for green tomatoes and could be due to the actual cutting treatment for light red tomatoes. Some publications indicate that skin removal is not suitable treatment for light red tomatoes. Some publications indicate that skin removal is not suitable for texture measurements of firmness in tomatoes which is supported by my work. However, it is important to specify whether the skin was removed or not in reporting firmness measurements.

References

1. Geeson, J.D., K.M. Browne, K. Maddison, J. Shepherd and F. Guarald. Modified Atmosphere Packaging to Extend the Shelf Life of Tomatoes. Journal of Food Technology. 20: 339-349. 1985.
2. Yang, C.C. and M.S. Chinnan. Computer Modelling of Gas Composition and Colour Development of Tomatoes Stored in Polymoric Films. Journal of Food Science. 53, 869-872. 1988.
3. Burton, W.G. Ripening and senescence of fruits. In (Ed) W.G. Burton. Post-harvest physiology of food crops. Logman Group Ltd., p: 181-198. 1982.
4. Gormley, R.S. and S. Egan. Firmness and Colour of the Fruit of Some Tomato Cultivars From Various Sources During Storage. J. Sci. Food Agric. 29: 534-538. 1978
5. Kader, A.A., L.L. Morris and P. Chen. Evaluation of Two Objective Methods and Subjective Rating Scale For Measuring Tomato Firmness. J. Amer. Soc. Hort. Sci. 103: 70-73. 1978.
6. Curd, L. Destructive or non-destrucrive distortion of fruit for the evaluation of quality. Bsc. Thesis, Silsoe College Cranfield University, Silsoe, Beds, England MK45 4DT. 1987.
7. Geeson, J.D. and K.M. Browne. New Packaging Technology Aims to Extend Shelf Life. Grower. July 14, p: 35-38. 1983.
8. Hobson, G.E. The firmness of tomato fruit in relation polygalacturonase activity. J. Hort. Sci. 40, 66-72. 1965.

9. Hobson G.E. Low-Temperature Injury and The Storage of Ripening Tomatoes. Journal of Horticultural Science 62(1)55-62. 1987.

10. Hobson, G.E. The Short Term Storage of Tomato Fruits. Journal of Horticultural Science. 56(4): 363-368. 1981.

11. Ghafir, S. and A.K. Thompson. Desructive and non-desructive apple maturity and ripeness assessments. Agricultural Enginer. Summer, 40-43. 1994.

12. Thomas, T.H., L.K. Drew & P.W. Goodenough. Determination of Firmness of Field-Grown Tomato During Storage in Controlled Atmosphere or Ripened at Different Temperatures. Ann. Appl. Biol., 100: 197-202. 1982.

13. Esquerra, E.B. and D.K. Bautista. Modified Atmosphere Storage and Transport of 'Improved Pope' Tomatoes. ASEAN Food Journal. 5, 27-33. 1990.

14. Tong, C.B. and K.C. Gross. Ripening Characteristics of a Tomato Mutant, Dark Green. Journal Amer. Soc. Hort. Sci. 114(4): 635-638. 1989.

15. Risse, L.A., W.R. Miller and R.E. McDonald. Effects of film wrapping on mature green tomatoes before and after ethylene treatments. Proc. Fla. State Hort. Soc. 97, 112-114. 1984.

16. Risse, L.A., W.R. Miller ve S. Ben-Yehoshua. Weight Loss, Firmness, Colour and Decay Development of Individual Film Wrapped Tomatoes. Tropical Science. 25: 117-121. 1985.

17. Yang, C.C., P. Brennan, M.S. Chinnan and R.L. Shewfilt. Characterisation of Tomatoes Ripening process As Influenced by Individual Seal-Packaging and Temperature. Journal of Food Qouality. 10: 21-33. 1987.

18. Geeson, J.D. K.M Browne and F. Guaraldi. The Effects of Ethylene Concentration in Controlled Atmosphere Storage of Tomatoes. Ann. appl. Biol., 108, 605-610. 1986.

19. Geeson, J.D. Modified Atmosphere Packaging of Fruit and Vegetables. Acta Horticulture. 258: 143-150. 1989.

20. Adegoroye, A.S., P.A. Jolliffe and M.A. Tung. Texture Characteristics of Tomato Fruits (Lycopersion esculentium) Affected by Sunscald. Journal of Science Food Agriculture. 49, 95-102. 1989.

21. Batu, A. ve A.K. Thompson. Effects of Cross-head Speed and Probe Diameter on Instrumental Measurement of Tomatoes Firmness. ProCeedings of the International Conference for Agricultural Machiney and ProCess Engineering October 19-22. Seoul, KOREA. p: 1340-1345. 1993.

22. Batu, A. Controlled and Modified Atmosphere Storage of Tomatoes. PhD Thesis. Cranfield University, Silsoe College, Silsoe, Beds. MK45 4DT. England. 1995.

23. Dilley, D.R., E Lange and K. Tomako. Optimizing paremeters for controlled atmosphere storage of apples. In Controlled Atmosphere Research Conference Fifith Proceding. Wenatchee, Washington, USA. p: 221-236. 1989.

24. Fica, J.J., Skrzyaski and D.R. Dilley. The effect of cooling and delayed application of CA storage of McIntosh apples under low and high ethylene levels. In Controlled atmosphere for storage and transport of perishable agricultural commodities. Fouth National Controlled Atmosphere Reseach Conference. Reilgh, Nort Carolina. p: 82-94. 1985.

25. Porritt, S.W. and M.M. Meheriuk. Effectc of CO_2 treatment on storage below or of apples and pears. In Horticultural Report. Controlled atmospheres for the stage and transport of perishable agricultural commodities. Second National Controlled Atmosphere Research Conference. Michigan State Univ. USA. p: 170-174. 1977.

26. Smith, S.M., S.D. Geeson, P.M. Genge and P.O. Sharples. The effects of modified atmosphere packaging and stage of ripeness on the quality of English pears during simulated marketing. In International Conference on Technical Innovations in Freezing and refrigeration of fruits and vegetables. Wellmann Hall, Univ. of California. Davis. USA. p: 315-324, 1989.

27. Ilangantileke, S. and V. Salokhe. 1989. Low pressure atmosphere atmosphere storage of thai mango. In Controlled Atmosphere Research Conference Fifith Proceding. Wenatchee, Washington, USA. P: 103-117. 1989.