Changes in the fruit texture parameters and composition of apricot cultivars during ripening

Article *in* Acta Alimentaria · September 2012

DOI: 10.1556/AAlim.41.2012.Suppl.7

Acta Alimentaria, Vol. 41 (Suppl.), pp. 73–82 (2012)
DOI: 10.1556/AAlim.41.2012.Suppl.7

CHANGES IN THE FRUIT TEXTURE PARAMETERS AND COMPOSITION OF APRICOT CULTIVARS DURING RIPENING

V. HAJNAL*, L. SZALAY, SZ. NÉMETH, G. FICZEK, G. BUJDOSÓ and M. TÓTH

Department of Pomology, Faculty of Horticultural Science, Corvinus University of Budapest, H-1118 Budapest, Villányi út 29–43. Hungary

Apricot is an important fruit species in Hungary both for fresh consumption and processing. Physical parameters and change of nutrients of nine apricot cultivars were studied during the ripening period. Four Hungarian and five North-American apricot cultivars were chosen for investigation. Changes in the physical parameters were measured by three different methods (Magness-Taylor hand penetrometer, Bookfield CT3 Texture Analyser with TA 44 and TA 9 measuring head). Significant differences in flesh firmness among the cultivars were observed mainly at the beginning of ripening time. Adhesiveness, cohesiveness and chewiness of the fruits decreased continuously during ripening. The studied cultivars showed significant differences in these traits. Sugar and acid contents were also measured during ripening. The cultivars showed small differences in sugar content and bigger differences in acid content of the fruits. Our data measured and collected during this study can be useful in characterizing the apricot cultivars studied. Changes in the texture parameters responsible for transportability and the technological usability of the fruits were described across the whole ripening period. Our results may help growers as well as food technologists to determine the optimum harvest date of cultivars intended to be used for different purposes.

Keywords: *Prunus armeniaca* L., ripening process, flesh firmness, hardness, composition

Hungary has a long-term tradition in apricot growing (*Prunus armeniaca* L.), this fruit species is a real so-called Hungaricum (PÉNZES & SZALAY, 2003). Apricot plays an accentuated role in the health-care nutrition as fresh fruit and processed product because of its valuable composition, fibre, mineral and antioxidant content, and colour material (NÉMETH et al., 2011).

Apricot fruits can be tree-ripened, but to a certain degree fruit ripening is continued after picking (after-ripening). The changes in the respiration intensity are typical for climacteric fruits, colour and composition of fruits change favourably after harvest under suitable storage conditions (PÉNZES & SZALAY, 2003).

Both fresh fruit market and processing industry need apricots of good fruit quality and excellent composition. Fruit quality is a complex phenomenon including physical, chemical, physicochemical characteristics, essentially determining consumer preference (STOW, 1995; SZALAY & BALLA, 2003). There are different demands on apricot fruit quality based on processing purposes. Fresh market prefers fruits with attractive appearance, good transportability and long shelf-life. Processing industry takes into consideration different fruit quality parameters (flesh firmness, taste, attractive flesh colour, suitable health status) depending on the type of product (HORVÁTH, 2003). Beside fresh consumption, marmalade and jam manufacturing, as well as canned apricot and juice have an important role in Hungary (SZALAY, 2009).

Flesh firmness is a basic property for the apricot (BUREAU et al., 2006), and is often used as an index of harvest maturity and it is important for processing apricots, depending on the

* To whom correspondence should be addressed.
Phone: 0036-482-6498; fax: 0036-482-6337; e-mail: veronika.hajnal@uni-corvinus.hu

particular industrial use (Bruhn et al., 1991). Qualitative and quantitative characteristics of apricots are inheritable, depending on certain genomes (Asma & Ozturk, 2005; Ruiz & Egea, 2008), but they can be modified by environmental factors and growing technology (Crossa-Raynaud & Audergon, 1991).

Flesh firmness decreases continuously during ripening, the fruit becomes softer. Speed of this change is genetically regulated, and influenced by environmental conditions (Szalay & Balla, 2003).

Measuring of flesh firmness of apricot fruits by Magness-Taylor hand penetrometer is reported in the literature; it measures the penetration force, and the tension calculation is based on the difference between the force of penetration (destruction tension) and that of deformation (Szalay & Balla, 2003; Farina et al., 2010; Leccese et al., 2010).

This fast examination method is suitable for flesh firmness determination but accurate, results can only be obtained by laboratory instruments. Complex texture profile analysis can be carried out by using modern Texture Analyser instrument. This tool has different probes and besides flesh firmness a number of other characteristics can be also determined, like fractuability, cohesiveness, springiness, chewiness, etc. (Bourne et al., 1966; Bourne, 1978; 1982). Flesh softening is related with the pectin degradation in the fruits. It is most studied in the case of apples (Ficzek et al., 2011).

Soluble solid content increased during ripening according to Durmaz and co-workers (2010). Based on the literature data the average amount of sugar content is 6.05% (minimum: 1.57%, maximum: 11.85%) in apricot (Ghorpade et al., 1995). A minimum value of 10.2 °Brix is required for fruit juice production (AIJN, 1997).

Acid content of fruits is decreasing during ripening. The main acid components are citric, malic, succinic and galacturonic acids in the apricot fruits (Anet & Reynolds, 1955). Optimal ratio of sugars and acids has a good effect on taste of fruits (Azodanlou et al., 2003). The picking time essentially determines the fruit quality (Aubert et al., 2010; Farina et al., 2010; Stéger-Máté et al., 2010).

Physical parameters and changing in nutrients of four Hungarian and five American apricot cultivars were examined during ripening. Flash firmness was measured by three different methods, and the results were compared. Our aim was to help food technologists in choosing the best quality fruits for processing.

1. Materials and methods

1.1. Cultivars and sampling

Trial was carried out during the apricot ripening season in 2011. Samples were collected from the orchard of Soroksár (Experimental Field of Corvinus University of Budapest). Trees, grafted on ‘Myrobalan’ rootstock, were planted in spring of 2004. Orchard density was 5×3 m. Canopies were treated as rule of compact vase.

Examinations were made in the laboratory of Corvinus University of Budapest, Department of Pomology, Faculty of Horticultural Sciences. Four traditional Hungarian cultivars: ‘Budapest’, ‘Ceglédi arany’, ‘Gönci magyar kajszi’, ‘Mandulakajszi’, and five North-American cultivars: ‘Hargrand’, ‘Harlayne’, ‘Harogem’, ‘Laycot’, ‘Veecot’ were involved in the trial.

Ten fruits from each cultivar were used for each examination. Samples of all involved cultivars were collected three times during the ripening period (at 70%, 80%, 90% maturity).

As the fruits of the cultivars do not ripe at the same time, picking times were adjusted to ripening status of the cultivar. Ripening stages of the cultivars were determined by colour scale of Tomcsányi, where 4 to 5 basic colour scale values meant 70% maturity, values of 5.5 to 6 were equal to 80% maturity, 7 to 8 ground colour scale values denoted maturity of 90% (Tomcsányi, 1963).

1.2. Determination of flesh firmness

Flesh firmness was determined with three methods. First method: Magness-Taylor hand penetrometer having heads with 8 mm in diameter, 0.5 cm^2 surface. Second and third measurements were carried out with Bookfield CT3 Texture Analyser texture profile. The baseboard was TA-RT-KIT with TA 44 measuring head and TA 9 pin shape probe. TA 44 type head had 4 mm diameter and 0.125664 cm^2 surface. Instrument settings were as follows: test type pin shape TPA and Compression with head type TA 44, target type: distance, trigger load: 4.0 g, test speed: 1 mm s^{-1}, target value: 10 mm. Flesh firmness values were measured with hand penetrometer and TA 44 head were represented in kp cm^{-2}, which is quotient of penetration force and surface of the head. Hardness measured with TA test was given in grams, which meant the penetration force.

Results were evaluated by using TexturePro CT VI.2 Build 9 software. Besides flesh firmness, adhesion force and cohesive force, as well as chewiness were also determined using TA 9 pin shape probe.

1.3. Chemical quality analysis

Water soluble dry matter content was measured using ATAGO type PR-101 digital refractometer based on Codex Alimentarius Hungaricus (1995) regulation. Titratable acidity was determined using Hungarian Standard (1998) with 0.1 NaOH and phenolphthalein indicator. The sugar/acid ratio was calculated from the total soluble solids and the titratable acid content.

1.4. Statistical methods

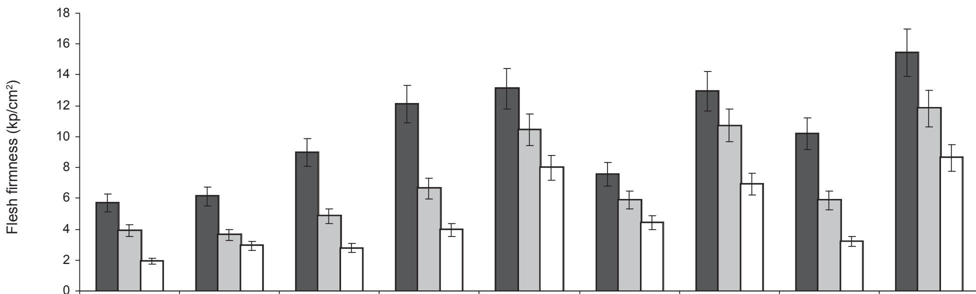
PASW 18.0 was used for statistical analysis. Multivariate analyses were made to separate the homogeneous groups using the Tukey HSD test. RSD value of the determination was 5% (n=10).

2. Results and discussion

2.1. Changing of flesh firmness during the ripening period

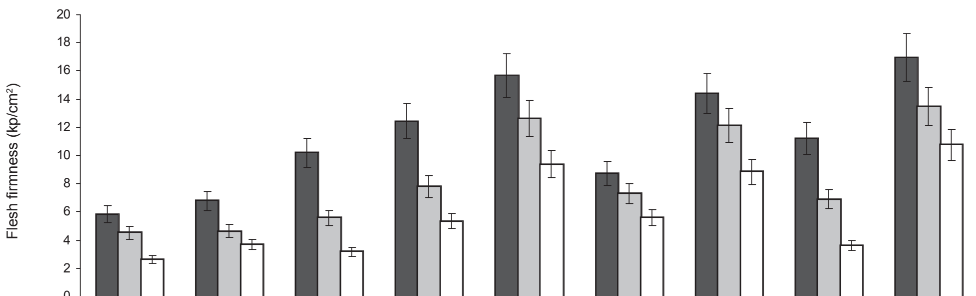
Results of the measurements with hand penetrometer and Texture Analyser with TA 44 measuring head are presented in Figs 1 and 2. All flesh firmness results are given in kp cm^{-2}, in order to allow comparison of data obtained by both instruments. Even though hand penetrometer probe had larger surface than the probe of Texture Analyser, results obtained using both methods were similar.

The differences between cultivars and the tendencies in changing firmness as a function of maturity were similar when measured by any of the two methods. Differences between the two methods were usually not larger than 4 to 5%, sometimes 10 to 15%. Reason of this phenomenon is that there are differences in resistance between direct flesh charring at the probe and cohesion to side of probe. Hand penetrometer resulted in lower flesh firmness data than using Texture Analyser. Results measured by Texture Analyser were more precise, therefore the analysis of cultivars and ripening were based on these data.



	Budapest	Ceglédi arany	Gönci magyar kajszi	Mandulakajszi	Hargrand	Harlayne	Harogem	Veecot	Laycot
70%	5.68	6.14	8.95	12.12	13.12	7.55	12.92	10.18	15.43
80%	3.91	3.62	4.86	6.63	10.43	5.9	10.72	5.87	11.84
90%	1.94	2.93	2.78	3.95	7.99	4.4	6.93	3.19	8.64

Fig. 1. Changing in apricot fruit flesh firmness measured by hand penetrometer during ripening in 2011



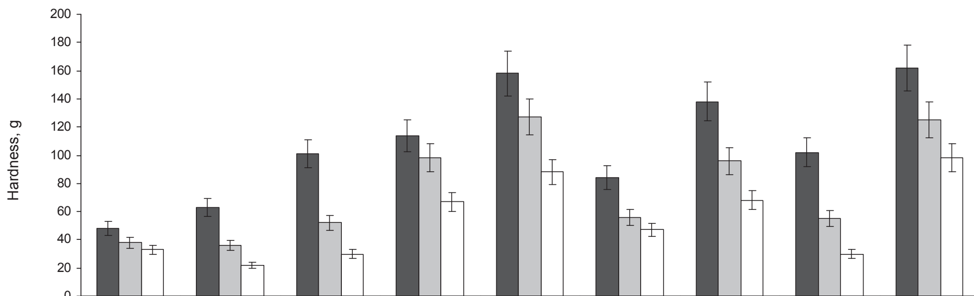
	Budapest	Ceglédi arany	Gönci magyar kajszi	Mandulakajszi	Hargrand	Harlayne	Harogem	Veecot	Laycot
70%	5.85	6.78	10.19	12.44	15.65	8.71	14.41	11.19	16.98
80%	4.51	4.61	5.57	7.81	12.63	7.29	12.14	6.9	13.47
90%	2.62	3.69	3.16	5.32	9.39	5.58	8.85	3.61	10.75

Fig. 2. Changing of apricot fruit flesh firmness measured by TA 44 probe during ripening in 2011

There were notable differences among cultivars mainly in flesh firmness at the beginning of 70% maturity, and the changes as a function of ripening was also characteristically different. Among the traditional Hungarian apricot cultivars ‘Budapest’ and ‘Ceglédi arany’ had the softest fruits, 5.85 and 6.78 kp cm^{-2} hardiness values were measured. Fruits of the other two Hungarian cultivars, ‘Gönci magyar kajszi’ and ‘Mandulakajszi’ were much firmer (10.19 and 12.44 kp cm^{-2}) at the beginning of ripening time but become soon softer than those of ‘Budapest’ and ‘Ceglédi arany’. Firmness of ‘Ceglédi arany’ and ‘Gönci magyar kajszi’ decreased by 45% and 69% between 70% and 90% maturity stages, and ‘Gönci magyar kajszi’ had softer fruits at 90% maturity, than ‘Ceglédi arany’. ‘Mandulakajszi’ produced 57% difference in firmness between 70% and 90% maturity, but this cultivar was not the firmest one among the examined cultivars.

'Laycot' had the firmest fruits among all examined cultivars at every maturity stages. Firmness of the three firmest cultivars (Hargrand, Harogem and Laycot) decreased only to a small extent during ripening. It also meant that the three firmest cultivars were firmer than the Hungarian cultivars at the ripening of 70 or 80%. Flesh firmness of 'Veecot' was similar to 'Mandulakajszi' and firmness of 'Harlayne' also showed similar tendencies to 'Gönci magyar kajszi', but softening of the fruits of 'Harlayne' was the slowest.

Results measured by using Texture Analyser TA 9 pin type probe are shown in Fig. 3. These results showed very similar tendencies to those measured by the two previous methods. There were just small differences among the cultivars because surface of probe was very small but cohesion of tissues to the side of the measuring head played a bigger role than in case of the other methods. Firmness value was given in grams (penetration force).



	Budapest	Ceglédi arany	Gönci magyar kajszi	Mandulakajszi	Hargrand	Harlayne	Harogem	Veecot	Laycot
70%	48	63	101	114	158	84	138	102	162
80%	38	36	52	98	127	56	96	55	125
90%	33	22	30	67	88	47	68	30	98

Fig. 3. Changing of apricot fruit hardness measured by TA 9 pin measuring head during ripening in 2011

Among traditional Hungarian apricot cultivars, fruits of 'Budapest', 'Ceglédi arany', 'Gönci magyar kajszi' were the softest and softened fast. SZALAY and BALLA (2003) measured similar flesh firmness values to those measured in this study. KOVÁCS and co-workers (2008) examined the firmness of fruits of 'Gönci magyar kajszi' using an instrument with pin probe, in four different maturity stages. Fast softening process was observed during the ripening period.

Of the North-American cultivar group 'Hargrand', 'Harogem' and 'Laycot' had extremely high flesh firmness at 70% maturity stage (15–16 kp cm^{-2}) and these values decreased slowly during ripening process compared to Hungarian cultivars (9–10 kp cm^{-2}). Fruit quality of 'Harlayne' and 'Veecot' was similar to that of the Hungarian cultivars.

2.2. Change in the flesh texture characteristics during ripening

The advantage of using TA 9 probe is that texture characteristics other than hardness (i.e. adhesiveness, cohesiveness and chewiness) can also be determined, because the pin penetrates twice through the tissues. These parameters are shown in Table 1.

The adhesive force decreased as the ripening advanced. 'Harogem' (2.45 mJ) had the highest adhesion value at 70% maturity; there were no significant differences in adhesion between the cultivars at 80% maturity, and 'Hargrand' (1.14 mJ) produced the highest value in 90% maturity. 'Laycot' and 'Mandulakajszi' were in the same statistical group as 'Hargrand'.

Table 1. Changing of adhesion, cohesion and chewiness of apricot fruits during the ripening, 2011

Cultivars	Adhesiveness (mJ)			Cohesiveness (mJ)			Chewiness (mJ)		
	Maturity stage, %			Maturity stage, %			Maturity stage, %		
	70	80	90	70	80	90	70	80	90
Budapest	0.56±0.098 a	0.42±0.04 a	0.37±0.09 a	0.23±0.02 ab	0.22±0.01 a	0.22±0.004 a	0.6±0.1 a	0.44±0.11 a	0.38±0.12 ab
Ceglédi arany	0.70±0.037 a	0.42±0.08 a	0.4±0.18 a	0.22±0.02 ab	0.23±0.02 a	0.25±0.04 a	0.77±0.41 ab	0.37±0.08 a	0.28±0.09 a
Gönci magyar kajszi	1.14±0.41 ab	0.53±0.15 a	0.44±0.13 a	0.28±0.09 ab	0.23±0.01 a	0.22±0.07 a	2.53±2.44 ab	0.64±0.37 a	0.35±0.25 ab
Hargrand	2.1±0.4 bc	1.97±1.31 a	1.14±0.27 c	0.28±0.02 ab	0.26±0.03 ab	0.23±0.02 a	2.87±0.31 ab	2.52±1.56 a	1.62±0.99 c
Harlayne	1.22±0.98 ab	0.6±0.18 a	0.55±0.03 ab	0.23±0.05 ab	0.21±0.02 a	0.23±0.01 a	1.44±1.01 ab	0.68±0.23 a	1.08±0.53 ab
Harogem	2.45±1.31 c	1.12±0.16 a	0.81±0.11 bc	0.29±0.03 b	0.27±0.01 ab	0.24±0.02 a	3±1.35 ab	1.57±0.26 a	0.96±0.13 ab
Laycot	2.26±0.62 bc	1.35±0.34 a	1.11±0.26 c	0.25±0.03 ab	0.25±0.02 ab	0.23±0.01 a	3.94±3.26 b	1.93±0.87 a	1.75±0.47 c
Mandula-kajszi	1.51±0.44 ab	1.22±2.58 a	0.93±0.13 c	0.31±0.06 b	0.30±0.19 b	0.28±0.03 a	2.25±0.82 ab	1.91±5.53 a	1.19±0.31 bc
Veecot	1.04±0.37 ab	0.65±0.15 a	0.53±0.12 ab	0.2±0.03 a	0.22±0.02 a	0.24±0.03 a	1.49±1.29 ab	0.49±0.22 a	0.37±0.11 ab

Letters ‘a’, ‘b’ and ‘c’ mean homogeneous groups in current columns by Tukey’s test, $P<0.05$

'Mandulakajszi' (0.1 mJ) and 'Harogem' (0.29 mJ) had the highest cohesion between the cells at 70% maturity. Cohesion values of the other cultivars were in the same statistical group except for 'Veecot' (0.2 mJ), which produced the smallest value. Extremely high cohesion force was detected for 'Mandulakajszi' (0.3 mJ) at 80% maturity. There were no significant differences in cohesion force among the cultivars at 90% maturity stage (Table 1).

Chewiness decreased during the whole ripening period. 'Laycot' (3.94 mJ) produced the highest value at 70% maturity. At maturity of 80%, all chewiness values were the same, belonging to the same statistical group. Chewiness values of 'Laycot' (1.75 mJ) and 'Hargrand' (1.62 mJ) were extremely high in case of fruits in 90% maturity (Table 1).

2.3. Change of nutrients during ripening

Total soluble solid (TSS) content of the examined fruits increased continuously during ripening, but the titratable acid content (TA) decreased (Table 2). Sugar content (TSS) of 'Hargrand' and 'Budapest' were the highest, and that of 'Veecot' and 'Laycot' were the lowest at 70% maturity. At 80% maturity 'Budapest' had the highest and 'Veecot' showed the lowest sugar content. 'Hargrand' produced the highest and 'Harogem' the lowest sugar content at ripening of 90%. As the result of the statistical analysis there were two significance groups in 70% and 90% maturity, and three groups at ripeness of 80% (Table 2).

There were also Hungarian and foreign cultivars in every statistical group. Acid content of 'Gönci magyar kajszi' and 'Mandulakajszi' was the highest at 70% maturity stage. At 80% and 90% maturity stages the highest acid content was produced by 'Harogem' and 'Mandulakajszi'. 'Ceglédi arany' had the lowest acid content in every examined ripening stage (Table 2).

Acid content of 'Harogem' changed in the least during ripening. The cultivars can be divided to five groups in case of 70% and 90% maturity stage, and to six groups at 80% maturity, being the differences in acid content much greater than in case of sugar. There were no significant differences in acid content among the Hungarian and foreign cultivars (Table 2).

The nutrient data were similar to those published by Souci and co-workers (1989).

There were big differences in sugar/acid ratio of the cultivars investigated, due to the great differences in acid content (Table 2).

3. Conclusions

Qualitative and quantitative characteristics of apricot fruits are encoded in genome, and it explains the great differences between cultivars. In our study the change in flesh firmness, texture parameters, and nutrient values of nine apricot cultivars were examined at different ripening stages. Flesh firmness was measured with three different methods. All methods showed the same tendencies. There were significant differences in flesh firmness (hardness) among the cultivars mainly at the beginning of ripening time (70% maturity). Processing industry prefers different fruit quality parameters, mainly flesh firmness, for different purposes. Based on our results apricot cultivars 'Hargrand', 'Harogem' and 'Laycot' with high flesh firmness are suitable for canning, cultivars 'Budapest', 'Ceglédi arany', 'Gönci magyar kajszi' and 'Harlayne' having softer flesh firmness are suitable for jam, jelly and aseptic puree. Change of fruit characteristics during ripening were examined also using pin probe. Adhesiveness, cohesiveness, and chewiness decreased continuously during ripening. There were big differences in these values between the cultivars. Changing in sugar and acid

Table 2. Changing of soluble dry matter content, acid content and sugar/acid ratio of apricot fruits during the ripening, 2011

Cultivars	Total soluble solids (Brix%)			Titratable acid (%)			Sugar/acid ratio		
	Maturity stage, %			Maturity stage, %			Maturity stage, %		
	70	80	90	70	80	90	70	80	90
Budapest	13.96±1.39 ab	17.37±1.31 c	17.94±0.36 b	1.61±0.05 b	1.37±0.05 b	1.35±0.06 b	8.67±0.87 c	12.7±0.77 f	13.32±0.75 d
Ceglédi arany	13.12±0.96 a	13.96±0.8 a	15.72±1.29 a	1.21±0.05 a	1.07±0.04 a	0.93±0.04 a	10.84±0.95 d	13.04±1.1 f	16.85±1.16 e
Gönci magyar kajszi	12.51±1.93 a	13.96±0.83 a	15.55±2.53 a	2.25±0.09 e	1.85±0.07 de	1.3±0.05 b	5.57±0.9 a	7.58±0.6 ab	12.03±2.03 cd
Hargrand	15.75±1.58 b	16.77±0.81 bc	18.51±1.07 b	2.05±0.09 d	1.48±0.06 b	1.35±0.06 b	7.69±0.93 c	11.33±0.81 e	13.71±0.55 d
Harlayne	12.59±0.8 a	14.84±1.54 a	15.57±1.4 a	1.78±0.07 bc	1.65±0.06 c	1.63±0.06 d	7.1±0.61 bc	9±0.87 cd	9.57±0.98 ab
Harogem	12.8±0.95 a	14.24±1.12 a	15.11±1.04 a	2.07±0.08 d	1.99±0.08 f	1.79±0.07 e	6.2±0.57ab	7.17±0.48a	8.47±0.64 a
Laycot	12.28±1.13 a	15.14±1.39 ab	15.67±1.27 a	1.9±0.08 c	1.65±0.07 c	1.49±0.06 c	6.44±0.52 ab	9.22±1.04 d	10.56±1.07 bc
Mandulakajszi	13.74±1.18 a	15.23±2.39 ab	16.92±0.84 ab	2.27±0.22 e	1.97±0.08 e	1.85±0.07 e	6.1±0.6 ab	7.75±1.34 ab	9.17±0.7 ab
Veecot	12.28±2.1 a	13.91±0.98 a	15.37±0.53 a	1.91±0.08 c	1.8±0.22 d	1.69±0.07 d	6.43±1.35 ab	7.73±0.97 ab	9.08±0.55 a

Letters ‘a’, ‘b’,‘c’, ‘d’, ‘e’ and ‘f’ mean homogeneous groups in current columns by Tukey’s test, $P<0.05$

content was also tracked during ripening. The cultivars investigated showed small differences in sugar content and greater differences in acid content. Our results complement the description of apricot cultivars and may help experts to determine the optimum harvest date of cultivars for different purposes.

*

Our research was supported by GOP-1.1.1-09/1-2009-0042 and TÁMOP-4.2.1/B-09/1/KMR-2010-0005 projects.

References

AIJN (1997): Code of practice for evaluation of fruit and vegetable juices. AIJN, Brussels.

Anet, E.F.L.J. & Reynolds, T.M. (1955): The separation of acids on anion exchange resins: The isolation of 1-quinic acid from apricots. *Aust. J. Chem., 8,* 280.

Asma, B.M. & Ozturk, K. (2005): Analysis of morphological, pomological and yield characteristics of some apricot germplasm in Turkey. *Genetic Resources and Crop Evolution, 52,* 305–313.

Aubert, C., Bony, P., Chalot, G. & Hero, V. (2010): Changes in physiochemical characteristics and volatile compounds of apricot (*Prunus armeniaca* L. cv Bergeron) during storage and post-harvest maturation. *Fd Chem., 119,* 1389–1398.

Azodanlou, R., Darbellay, C., Luisier, J., Villetaz, J. & Amadó, R. (2003): Development of a model for quality assessment of tomatoes and apricots. *Lebensm.-Wiss. Technol., 36, 223–233.*

Bourne, M.C. (1978): Texture profile analysis. *Fd Technol., 32,* 62–66, 72.

Bourne, M.C. (1982): *Food texture and viscosity.* Academic Press Inc., New York, 330 pages.

Bourne, M.C., Moyer, J.C. & Hand, D.B. (1966): Measurement of food texture by an universal testing machine. *Fd Technol., 20,* 522.

Bruhn, C.M., Feldman, N., Garlitz, C., Harwood, J., Ivans, E. & Marshall, M. (1991): Consumer perceptions of quality: apricots, cantaloupes, peaches, pears, strawberries and tomatoes. *J. Fd Quality, 14,* 187–195.

Bureau, S., Chahine, H., Reich, M. & Albagnac, G. (2006): Fruit ripening of contrasted apricot varieties: physical, physiological and biochemical changes. *Acta Hort., 701,* 511–515.

Codex Alimentarius Hungaricus (1995): *Élelmiszerek vízoldható szárazanyag tartalmának meghatározása.* (Determination of total soluble solids in foods.) No. 3-1-558/93.

Crossa-Raynaud, P. & Audergon, J.M. (1991): Some reflexions on apricot selections. *Acta Hort., 293,* 73–85.

Durmaz, G., Çam, M., Kutlu, T. & Hişil, Y. (2010): Some physical and chemical changes during fruit development of five common apricot *(Prunus armeniaca* L.) cultivars*. Fd Sci. Technol. Res., 16*, 71–78.

Farina, V., Volpe, G., Mazzaglia, A. & Lanza, C.M. (2010): Fruit quality traits of two apricot cultivars. *Acta Hort., 862,* 593–598.

Ficzek, G., Stéger-Máté, M., Nótin, B. & Tóth, M. (2011): Changing of texture and pectin content of Hungarian bred apple genotypes during the storage. *Proceedings of the 11th International Congress on Engineering and Food. Food Process Engineering in a Changing World.* Athens, Greece 2011. Vol. II. pp. 1115–1117.

Ghorpade, V.M., Hanna, M.A. & Salunkhe, D.K. (1995): 'Apricots'. -in: Salunkhe, D.K. & Kadam, S.S. (Eds) *Handbook of fruit science and technology: Production, composition, storage and processing.* (Vol. I), Marcel Dekker, New York, pp. 335–361.

Horváth, D. (2003): A kajszi feldolgozása, tartósítása (Processing of apricot). -in: Pénzes, B. & Szalay, L. (Eds) *Kajszi.* (Apricot.) Mezőgazda Kiadó, Budapest, pp. 371–378.

Hungarian Standard (1998): *Gyümölcs- és zöldséglevek. A titrálható savasság meghatározása.* (Fruit and vegetable juices. The determination of titratable acidity.) No. MSZ EN 12147:1998.

Kovács, E., Merész, P., Kristóf, Z. & Németh-Szerdahelyi, E. (2008): Ripening and microstructure of apricot (*Prunus armeniaca* L.). *Acta Alimentaria, 37,* 23–39.

Leccese, A., Bureau, S., Reich, M., Renard, M.G.C.C., Audergon, J.M., Mennone, C., Bartolini, S. & Viti, R. (2010): Pomological and nutraceutical properties in apricot fruit cultivation systems and cold storage fruit management. *Pl. Foods Human Nutr., 65,* 112–120.

Németh, Sz., Szalay, L., Ficzek, G., Stéger-Máté, M., Sándor, G., Végvári, Gy. & Tóth, M. (2011): Analysis of chemical parameters determining the fruit quality of apricot cultivars during ripening. *Acta Alimentaria, 40* (Suppl.), 109–119.

Pénzes, B. & Szalay, L. (2003): *Kajszi.* (Apricot.) Mezőgazda Kiadó, Budapest. 400 pages

Ruiz, D. & Egea, J. (2008): Phenotypic diversity and relationships of fruit quality traits in apricot (*Prunus armeniaca* L.) germplasm. *Euphytica, 163,* 143–158.

Souci, S.W., Fachmann, W.C. & Kraut, H. (1989): *Food composition and nutrition tables.* Wissenschaftliche Verlagsgesellschaft GmbH, Stuttgart, 1027 pages.

Stéger-Máté, M., Ficzek, G., Kállay, E., Bujdosó, G., Barta, J. & Tóth, M. (2010): Optimising harvest time of sour cherry cultivars on the basis of quality parameters. *Acta Alimentaria, 39,* 67–73.

Stow, J. (1995): Quality measurements of apples. *Postharvest News Inf., 6,* 32–33.

Szalay, L. (2009): Kajszi. (Apricot.) -in: Tóth, M. (Ed.) *Gyümölcsfaj- és fajtaismeret*. (Knowledge of fruit species and cultivar.) Inkart Kft, Budapest, pp. 127–136.

Szalay, L. & Balla, Cs. (2003): Szüret, szüret utáni műveletek. (Harvest, post-harvest technologies.) -in: Pénzes, B. & Szalay, L. (Eds) *Kajszi.* (Apricot.) Mezőgazda Kiadó, Budapest, pp. 338–367.

Tomcsányi, P. (1963): *A gyümölcs útja a fától a fogyasztóig*. (The way of fruit from the tree to the consumer) Mezőgazdasági Kiadó, Budapest, 298 pages.