

## ASSESSMENT OF HARVEST TIME FOR RED DELICIOUS CV. THOUGH HARVEST INDEXES IN ALBANIA

P. ICKA and R. DAMO

*University Fan S. Noli, Department of Agronomy, Bulevardi Rilindësit 11, Korça, Albanian*

### Abstract

ICKA, P. and R. DAMO, 2014. Assessment of harvest time for Red Delicious cv. though harvest indexes in Albania. *Bulg. J. Agric. Sci.*, 20: 628-632

The apple fruits are one of the most profitable crops in Albania. The increase to the number and surface of orchards during last decade is accompanied by storage problems. One of the major problems in apple storage is the determination of optimal harvest time. The traditional maturity indicators do not give the clear situation of maturity processes, for this reason usage of maturity indexes contribute in the determination of optimal harvest time for apple orchards. Calculated values of the indexes Streif (0.075 – 0.10), De Jager (5.0 – 6.0), FARS (0.2 – 0.3) and Thiault (150) indicate that the optimal harvest time for Red Delicious apples in Korça region is from 20<sup>th</sup> September up to 1<sup>st</sup> October. This harvest time is indicated also by the proposed Ripening index (-1 – 1), while Sugar/acidity ratio (40 – 50) and Perlum index (4.3 – 4.6) give an approximate harvest time but these indexes show the trend of fruit maturity.

*Kew words: apple, Red Delicious, maturity index, harvest time, Ripening index*

### Introduction

Apple (*Malus × domestica* Borkh.) belongs to the main fruit species and they are the most important fruit in Europe (Patzak et al., 2012), and one of the most consumed in Albania with 19 kg/year/capita (USAID, 2008). Korça region produces almost 70% of the apples grown in Albania, with approximately 40,000 tons fruits per year. Therefore it is very important to evaluate and to suggest the harvest indexes in accordance with consumer's tastes and preferences.

Apples are subjected to major quality loss during harvest and postharvest treatments (Ozturk et al., 2012). Storage conditions determine the longevity of storage life of apples (Blažek et al., 2003), and to ensure maximum storability, apples should be picked when mature, but not fully ripe. Later picked apples often are over mature and all physiological processes are underway what complicate storage, even under optimal conditions (Kviklené et al., 2008). Apples picked at right stage have the organoleptic qualities, which enable them to survive more than six months storage. If the optimal harvest period could be predicted well prior to harvest, it would also allow the grower to maximise harvest labour use efficiency (Peirs et al., 2001).

Establishing the optimum harvest date is an important factor in obtaining quality fruits. The best way to provide customers with good quality apples is to select the most appropriate harvest date to guarantee consumer acceptance (Streif, 1996; Peirs et al., 2001; Molina et al., 2006). Quality of apple is consisted of a combination of visual appearance, flavor and texture (Ozturk et al., 2012). The maturity level, color, size, mechanical defect (Ozturk et al., 2012), and firmness (Ozturk et al., 2011; Ozturk et al., 2012) are important factors for apple marketing, because in apples, fruit appearance is very important factor (Kacal and Koyuncu, 2012.). Measurements of soluble solid content and titratable acidity are often included in assessments of the postharvest quality of apples (Goliáš et al., 2008). Therefore it is necessary to assess the quality of apple fruit picked on different dates. It is hoped that these findings will help the apple growers a lot to pick their fruits at proper time and store them in cold storage with minimum losses to present the fruits of best qualities to consumers too (Ullah et al., 2004). The determination of optimum harvest date has become more severe since storage facilities are getting precisely controlled requiring adequate fruit material (Zude-Sasse et al., 2000).

Maturity is the harvest index most widely used in fruits. However, physiological maturity needs to be distinguished from commercial maturity (Camelo, 2004). The most widely used maturity indicators for apples include flesh firmness, starch content, sugar content (°Brix), fruit colour, and internal ethylene concentration. The following attributes are also used as supplemental maturity indicators: titratable acidity content, days from full bloom, and temperature accumulation. Fruit harvested at optimum maturity and handled properly has good storability and good eating quality (Bai et al., 2009).

To stabilize the best harvest date it is good practice to refer not only on one indicator, but to consider different at the same time. Some indicators may be combined together to obtain the harvest indexes (Bufacchi et al., 2000). Among these the most important are: Streif index, De Jager index, Thialut index, FARS index etc.

In this study we have measured four indicators, total soluble solids (TSS), titratable acidity (A), starch degradation (S) and firmness (F), to compute six indicators for the optimum harvest date determination as well as prediction of fruit quality in Red Delicious apple.

## Materials and Methods

Korça Field is located in South East of Albania with an altitude 820 – 950 m above sea level. It has a Mediterranean continental climate, with dry and hot summer and cold and wet winter. It is the driest (760 mm rainfall per year) and coldest (up to – 27°C) region of Albania.

The orchard in the study is located 3 km on south-west of Korça city (40°35'35" N and 20°45'52" E) with an altitude 885 m above sea level. The soil texture of orchard is clay and soil quality index according Visual Soil Assessment is 18, classified as moderate (Damo and Icka, 2011). According the Standardized Precipitation Index evaluation the hydrological situation during the study period is mainly a normal situation except the year 2009 that is characterized by rainfall events (Icka et al., 2011).

The major apple cultivars growing in the Korça region are Red Delicious 52% and Golden Delicious 42% of apple orchards (USAID, 2008), for this reason it is very important to determine the best harvest time using the indexes for Red Delicious apples in this region. The evaluation of indicators to calculate the indexes was made during three years period study 2007 – 2009, for each estimated harvest date, 1<sup>st</sup> September, 20<sup>th</sup> September and 10<sup>th</sup> October. At least 40 fruit of Red Delicious are analyzed for four indicators:

**Starch iodine test (S)** indicates the gradual change of starch into sugars in the fruit. The starch iodine index was

determined according the EUROFRU with 1 – 10 score comparing the iodine treated fruits with the given figure. The iodine solution is prepared according Chu, 2000.

**Total soluble solids (TSS)**, are determined by using the WYA-2W ABBE refractometer at room temperature (20°C), the TSS is given as °Brix.

**Flesh firmness (F)** of peeled apple tissue is measured on both sides of fruits with Effegi penetrometer (FTX 30) fitted with 11 mm diameter probe, the F is given as kg/cm<sup>2</sup>.

**Acidity (A)** of fruit juice (given in g/L malic acid) is determined by titration of 10 ml apple juice with 1.0 M NaOH at pH=8.2.

Evaluation of the harvest time is made by using six harvest indexes that combine the above indicators:

**Streif index** (Streif, 1996; Hägg et al., 1999; Zude-Sasse et al., 2000; Peirs et al., 2001; Ullah et al., 2004; Alegre et al., 2006; Röth et al., 2007; Kviklené et al., 2008 ; Kviklys 2012)

$$\text{Streif index} = \frac{F}{TSS \times S}$$

**De Jager index** (De Jager, Roelofs, 1996; Bufacchi et al., 2000; Molina et al., 2006; Alegre et al., 2006):

**FARS index** (Alegre et al., 2006; Molina et al., 2006):

$$\text{FARS index} = \frac{F \times A}{TSS \times S}$$

**Perlim index** (Hägg et al., 1999):

$$\text{Perlim index} = (F \times 0,5 + TSS \times 0,67 + A \times 0,67) - 10$$

**Thiault index** (Hägg et al., 1999; Bufacchi et al. 2000; La Iacona et al., 2009):

$$\text{Thiault index} = TS + A \times 10$$

$$TS (\text{Total Sugar}) = (TSS \times 10,6) - 20,6$$

**Total Sugar/acidity ratio** (Bufacchi et al., 2000; OECD, 2005, 2009; Molina et al., 2006; Brown et al., 2006; Skrzyński et al., 2006; Dhatt et al., 2007; AA. VV., 2010):

$$\text{Total Sugar/Acidity ratio} = \frac{TSS \times 10}{A}$$

ANOVA was performed on the results of calculated indexes to determine the harvest time, and Fisher's least significant difference (LSD) intervals, at 95% and 99% confidence limits, are computed for each parameter.

## Results and Discussion

During three harvest times are evaluated the four indicators: total soluble solid (°Brix), acidity (g/l), starch iodine (1 –

10 scale) and firmness (kg/cm<sup>2</sup>) to calculate the indexes. The values of calculated indexes are given in Table 1.

**Streif index** values (Table 1) show a decrease during the fruit maturation and ripening, from 0.350 on the 1<sup>st</sup> September, 1.104 on 20<sup>th</sup> September and 0.048 on 10<sup>th</sup> October (\*\*P<0.01= 0.017). According the recommended values 0.19 – 0.47 (Bufacchi et al., 2000), 0.11 – 0.12 (Ullah et al., 2004), in our case this values are achieved between first harvest date, with the average value by 0.350, and second harvest date with the average value by 0.104. While Wilcke et al., (2002) recommends as an optimal value of the Streif index for Red Delicious by 0.06 and Veschugin, (2008) recommends that the index value should be between 0.069 – 0.072. Based on the results obtained after 120 days storage on refrigerator conditions (analyses for quality, organoleptic and storability, parameters that are not object of this paper), from this study and according the conditions of Korça region we recommend that the optimal value of the Streif index for Red Delicious should be in the interval 0.075 – 0.100.

Reduction of **De Jager index** values from 8.975 in 5.992 and 3.468, in three respective harvest dates (\*\*P<0.01 = 0.557). The diminution of this index values indicate the advance of ripening process. According Bufacchi et al., (2000) and Veschugin, (2008), for Red Delicious apples the best picked is when the values of De Jager index is within 6.0 and 4.2. These values in our study are achieved between 20<sup>th</sup> September and 10<sup>th</sup> October. Since the value of this index in 10<sup>th</sup> October is too low (over mature fruits), we recommend that for our case the values of De Jager index should be 5.0 – 6.0.

**FARS index** is the only index that uses four harvest indicators to be calculated (Firmness, Acidity, Total soluble solids (R) and Starch index). The values of this index, also, are fallen from 1.231 in the first picked date to 0.328 and 0.127 in other two picked dates (\*\*P<0.01 = 0.110). Recommended values according Alegre et al., (2006) are within 0.45 and 0.75, values that are achieved between first and second harvest date. But the fruits picked in this period are not mature, and according this we recommend that FARS index value for a good Red Delicious apple storability should be 0.2 – 0.3.

**Perlim index** values (Table 1) for each picked date are 4.930; 4.646 and 3.658 (\*\*P<0.01 = 0.758). Prolongations of the period that apples stay at the tree give over mature apple fruits and a decrease the index value. Wilcke, (2002), Wilcke et al., (2002) and Lafer, (2003) recommend for Red Delicious that Perlim index value should be within 3.0 and 5.0, but these values include a wide period of harvest, from the first harvest date to the third harvest date. In this condition we recommend that the value should be 4.3 – 4.6. Regardless this recommendation, for assessment of an optimal Perlim index value probably will need further studies.

**Thiault index** is one of most used index for evaluation of harvest time. According the statistical analyse the values of this index at second date (149.11) and third date (153.53) have significance difference with the index value at first date (137.21) for \*\*P<0.01 = 7.239, while between values of Thiault index at second and third date the differences are significantly for \*P<0.05 = 4.375. This index show that maturity of Red Delicious apple in Korça region is faster between 1<sup>st</sup> and 20<sup>th</sup> September, as the fruit matures, the values of this index are increased slowly. According the Thiault index, a fruit can be consider ripped when its value is between 160 – 178 (Wilcke, 2002; Wilcke et al., 2002; Lafer, 2003; Regolamento (CE) n. 510/2006 del consiglio «Mela Val di Non»; La Iacona et al., 2009) values that extend over the 10<sup>th</sup> October. While D' Aquino et al., (1997) indicate that optimal value of Thiault index for the Red Delicious is 152, this value is more acceptable for our study, and in this case we recommend that optimal value of Thiault index for the Red Delicious in Korça region is 150.

Calculated values of **Sugar/acidity ratio index** are: at 1<sup>st</sup> September 33.01, 20<sup>th</sup> September 41.53 and 10<sup>th</sup> October 52.44 (\*\*P<0.01 = 2.544). This index indicates that fruit become sweeter as it is become mature and over mature. According Wilcke, (2002) and Quartin, (2004), in the harvest time the ratio TS/A should be between 15 and 20, values that are too low to be considered in our study. The value recommended by PTFPG, 2010-2011 for e mature apple fruit should be TS/A>40, values that in our study are reached after the second

**Table 1**  
The mean values of indexes in three harvest dates for the Red Delicious Apple

	Streif index	De Jager index	FARS index	Perlimindex	Thiaultindex	TS/A index
1-Sep	0.350±0.059 <sup>a</sup>	8.975±0.917	1.231±0.226	4.930±0.383	137.21±4.631	33.007±1.662
20-Sep	0.104±0.013	5.992±0.608	0.328±0.052	4.646±0.486	149.11±6.646	41.526±3.444
10-Oct	0.048±0.006	3.468±0.494	0.127±0.018	3.658±0.373	153.69±4.544	52.437±5.282
*P<0.05	0.01	0.336	0.067	0.458	4.375	1.538
**P<0.01	0.017	0.557	0.11	0.758	7.239	2.544

<sup>a</sup> Standard deviation

harvest date. According our conditions we recommend that the value for TS/A index should be 40 – 50.

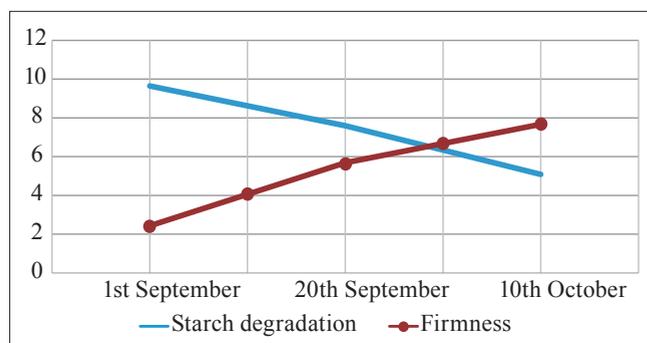
Evaluation of harvest time according the harvest indexes show that the optimal period of harvest for Red Delicious in Korça region is between 20<sup>th</sup> September and 1<sup>st</sup> October, which coincide with 150 – 160 day after blooming. The values of indexes Streif, De Jager, FARS, Perlim and Thiault, show a harvest time limited close the 20<sup>th</sup> September, while TS/A index indicate a wider period. The total sugar/malic acid ratio can be used to determine the trend of fruit ripening, but cannot be used as a single index for evaluating the harvest time for apples.

### The proposed harvest index

As far as the maturity of apple fruits are accompanied by the diminution of firmness values and by incense to the starch degradation values, we can put this data in a graphical situation to get the break point of the starch degradation ( $I_p$ ) and firmness (F) curves (Graphic 1). This break point in our study case is around 7 – 8 days after the second harvest date 20<sup>th</sup> September. This is the optimal harvest date estimated by the indexes above for the Red Delicious apples.

**Table 2**  
Recommended maturity indexes values and harvest time for Red Delicious in Korça region

Indexes	Red Delicious
Streif	0.075 – 0.10
De Jager	5.0 – 6.0
FARS	0.2 – 0.3
Perlim	4.3 – 4.6
Thiault	150
Sugar/Acidity	40 – 50
Ripening index ( $I_p$ )	-1 – 1
Recommended harvest time	20 September – 1 October



**Fig. 1.** Graphical presentation of firmness and starch degradation relationship

If these two harvest indicators are given as their difference, we can reach a new harvest index, the Ripening index ( $I_p$ ). As the values of firmness decrease and the starch index is increase, in one given moment the difference of these values is zero (in the breaking point). This value should be the best harvest time according the  $I_p$  index. This alternative index can formulate in the following expression:

$$I_p - \text{Ripening index} \\ I_a - \text{Starch index (1 - 10)} \\ F - \text{Firmness kg/cm}^2$$

A single value of the index usually is not easy to be estimated for the optimal harvest time, for this reason we propose that the interval of  $I_p$  value for a mature Red Delicious apples should be -1 – 1. This is an easy index to calculate because it takes only two simple indicators to be evaluated. For this region the Ripening index should be one of the most used harvest index in Korça region and further.

### Conclusion

Using the maturity indexes (Streif, De Jager, FARS, Thiault, Perlim, sugar/acidity ratio, Ripening index) is the best way to determine the harvest time for apples due to the consideration of two or more indicators for the calculation. According the values of calculated indexes the optimal harvest time for Red Delicious apple in Korça region is from 20<sup>th</sup> September till 1<sup>st</sup> October (Table 2). Sugar/acidity ratio and Perlim index are indexes that can be used to determine the maturity tendencies and the consumption maturity of fruits.

The proposed Ripening index may be one of most practical index due to its easiness on measuring and calculation. However this index should be studied to have the right values for harvest time in Korça region. For a continuous evaluation of the maturity indicators and indexes during the maturity period it is necessary to determine the right harvest time. This will help for a good storage and good practices on the orchards.

### References

- AA.VV. (Autori vari), 2010. Metodi innovativi di gestione dei frutti nella fase post-raccolta.
- Alegre, S., D. P. Molina, I. Recasens, M. Casals, J. Bonany, J. Carbó, T. Casero and I. Iglesias, 2006. Seasonal Trends in Harvest Indices for 'Golden Smoothie'® Apples in Spain. *Journal of Fruit and Ornamental Plant Research*, 14 (Suppl. 2).
- Bai, J., R. K. Prange and P. M. A. Toivonen, 2009. Pome fruits. In: Modified and controlled atmospheres for the storage, transportation, and packaging of horticultural commodities. Edited by Elhadi M. Yahia. Publisher: Boca Raton: CRC Press/Taylor & Francis.
- Blažek, J., I. Hlušíková and A. Varga, 2003. Changes in quality characteristics of Golden Delicious apples under different

- storage conditions and correlations between them. *Hort. Sci.*, **30** (3): 81–89.
- Brown, S. and K. Maloney**, 2006. What Constitutes Eating Quality to a New York Consumer and How Do We Measure Quality Objectively? *New York Fruit Quarterly*, **14** (4).
- Bufacchi, M., A. Lucaccioni, A. Motta, M. Marcelli and C. Casagrande**, 2000. Manuale di Corretta Prassi per la Produzione Integrata del Melo. 3A-Parco Tecnologico Agroalimentare dell'Umbria - Regione dell'Umbria.
- Camelo, A. F. L.**, 2004. Manual for the preparation and sale of fruits and vegetables. *FAO Agricultural Services Bulletin*, **151**.
- Chu George, C. L.**, 2000. Evaluating Maturity of McIntosh and Red Delicious Apples. *Factsheet Ontario*.
- D' Aquino, S., A. Piga and M. Agabbio**, 1997. Conserv Abilita' di Cultivar di Pero e Mlo del Germoplasma Autoctono Progetto Interreg I - Settore Agroalimentare "Caratterizzazione dei prodottialimentari dell'area sardo-corsa" Aula Magna della *Facolta di Agraria - Sassari* 11 aprile
- Damo, R. and P. Icka**, 2011. The assessment of an apple orchard with Visual Soil Assessment method. *AKTET*, **IV** (3). ISSN 2073–2244.
- De Jager, A. and F. Roelofs**, 1996. Prediction of the optimum harvest date of Jonagold. In: A. De Jager, A., Johnson, D., Hohn, H., (ed.), Determination and prediction of optimum harvest date of apples and pears. COST 94. European Commission, Luxembourg, pp. 21-31.
- Dhatt, A. S. and B. V. C. Mahajan**, 2007. Harvesting, Handling and Storage of Horticultural Crops.
- Goliáš, J., P. Mýlová and A. Nimcová**, 2008. A comparison of apple cultivars regarding ethylene production and physico-chemical changes during cold storage. *Hort. Sci.*, **35**(4): 137–144.
- Hägg, M., R. Ahvenainen, A. M. Ervers and K. Tiilikkala**, 1999. Agri Food Quality II, *Qaulitu Managment of Fruits and Vegetables*. ISBN 0-85404-788-3.
- Icka, P., R. Damo and L. Ekonomí**, 2011. The assessment of the rainfall events at the plain of Korça through the SPI. *AKTET*, **IV** (3). ISSN 2073–2244
- Kacal, E. and F. Koyuncu**, 2012. Use of chemical blossom thinners in 'Jerseymac' and 'Jonagold' apples. *Bulgarian Journal of Agricultural Science*, **18** (6): 898-904.
- Kviklené, N., D. Kviklys, J. Lanauskas and N. Uselis**, 2008. Harvest Time Effect on Quality Changes of Apple Cultivar Alva during Ripening and Storage. *Sodinidkyste ir Daržininkyste*, **27** (1).
- Kviklys, D., N. Kviklienė, A. Bite, J. Lepsis, T. Univer, N. Univer, N. Uselis, J. Lanauskas and L. Buskienė**, 2012. Baltic fruit rootstock studies: evaluation of 12 apple rootstocks in North-East Europe. *Hort. Sci.*, **39** (1): 1–7.
- La Iacona, T., F. Spanna, M. Sanna, E. Forni and C. Peano**, 2009. Caratterizzazione Ambientale e Produttiva dell'Areale Frutticolo Piemontese Occidentale.
- Lafer, G.**, 2003. European Network Chemical Thinning Fruit Corp – Potential trail Elstar 2003. *Eufirin Trail* 01-03
- Molina, D., S. Alegre, T. Casero, M. Casals, J. Bonany, J. Carbó and Puy, I. Recasens**, 2006. Quality indexes for 'Golden Smoothie' apples in relation to consumer evaluation. *Journal of Fruit and Ornamental Plant Research*, **14** (Suppl. 2): 39-51.
- OECD**, 2005. (Organisation for Economic Co-operation and Development). Guidelines on Objective Tests to Determine Quality of Fruits and Vegetables and Dry and Dried Produce.
- OECD**, 2009. (Organisation for Economic Co-operation and Development). Guidelines on Objective Tests to Determine Quality of Fruits and Vegetables and Dry and Dried Produce.
- Ozturk, B., E. Altuntas, Y. Ozkan and K. Yildiz**, 2012. Effect of AVG treatments on some physicochemical properties and color characteristics of apple (*Malus domestica* Borkh.). *Bulgarian Journal of Agricultural Science*, **18** (6): 889-897.
- Ozturk, I., S. Ercisli, M. Kara, Y. Erturk and F. Kalkan**, 2011. The genotypic effect on physical properties of three early matured apple cultivars. *Bulgarian Journal of Agricultural Science*, **17** (3): 333-338.
- Patzak, J., F. Paprštejn, A. Henychová and J. Sedlák**, 2012. Genetic diversity of Czech apple cultivars inferred from microsatellite markers analysis. *Hort. Sci.*, **39** (4): 149–157.
- Peirs, A., J. Lammertyn, K. Ooms and B. M. Nicolaï**, 2001. Prediction of the optimal picking date of different apple cultivars by means of VIS/NIR-spectroscopy. *ELSEVIER Postharvest Biology and Technology*, **21**: 189–199.
- Pennsylvania Tree Fruit Production Guide 2010–2011**. Growth Regulators in Apple and Pear Production.
- Quartín, V., J. C. Ramalho, A. P. Ramos and M. G. Barreiro**, 2004. Chlorophyll fluorescence as a non-destructive indicator for optimal harvest date of "Bravo de Esmolfé" apples. In: Maturação e Pós-Colheita 2004 - *Frutos e Hortícolas*, pps. 121- 125, ISBN: 972-579-028-6. M. Graça Barreiro/EANINIAP (Ed.), Oeiras, Portugal.)
- Regolamento (CE) n. 510/2006 del consiglio «Mela Val di Non»; (Regulation (EC) n. 510/2006 of the council «Apple of Val di Non»)**
- Róth, E., A. Berna, K. Beullens, S. Yarramraju, J. Lammertyn, A. Schenk, B. Nicolaï**, 2007. Postharvest quality of integrated and organically produced apple fruit. *Postharvest Biology and Technology*, **45**: 11–19.
- Skrzyński, J. and M. Gastol**, 2006. Quality of Jonica Apple Fruit as Influenced by Rootstocks" *Sodinidkyste ir Daržininkyste*.
- Streif, J.**, 1996. Optimum harvest date for different apple cultivars in the 'Bodensee' area. COST 94. The postharvest treatment of fruit and vegetables. Determination and prediction of optimum harvest date of apples and pears. *Proceedings of a meeting, Lofthus*, Norway, 9-10 June 1994. Pp. 15-20.
- Streif, J.**, 2008. Material zur Durchführung des Reifetests. Kompetenzzentrum Obstbau-Bodensee in Bavendorf (KOB)
- Ullah, J., N. Khan, T. Ahmad, M. Zafarullah, Y. Durrani**, 2004. Effect of Optimum Harvesting Date (OHD) on the Quality of Red Delicious Apple. *Asian Journal of Plant Science*, **3** (1): 65-68.
- USAID**, 2008. The Albanian Apple Value Chain Fskg Case Study.
- Veschugin, S. V.**, 2008. Varietal peculiarities of the quality of apple fruit in the garden for storage in the Lower Volga. Academic Degree for Candidate of Agricultural Sciences Thesis (Ru).
- Wilcke, C.**, 2002. Ernteterminbestimmung und Qualitätsvorhersage bei Äpfeln. Berichte aus dem Obstbau, Sächsische Landesanstalt für Landwirtschaft.
- Wilcke, C. and C. Wiedemann**, 2002. Apfel, Reife, innere Qualität. Fruchtausbildung und Einlagerwerte von Apfelsorten in Sachsen 2002.
- Zude-Sasse, M., B. Herold and M. Geyer**, 2000. Comparative Study on Maturity Prediction in 'Elstar' and 'Jonagold' Apples. *Gartenbauwissenschaft*, **65** (6). S. ISSN 0016–478X. Verlag Eugen Ulmer GmbH & Co., Stuttgart, pp. 260–265.