EVALUATION OF SOME QUALITATIVE CHARACTERISTICS OF NEW PLUM CULTIVARS

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Abstract

A study was done at the Latvia State Institute of Fruit-Growing, evaluating new domestic plum (*Prunus domestica* L.) selections, for which in 2008 -2010 some fruit quality characteristics were studied.

In result of evaluation four new cultivars were selected from the breeding material and in 2010 handed in for cultivar registration in Latvia. Cultivar 'Ance' is early ripening one month before 'Victoria'. Cultivar 'Adele' is medium ripening one week before 'Victoria'. Fruits keep well in cool storage. Cultivar 'Sonora' is medium ripening one week after 'Victoria' and self-fertile. Fruits of this cultivar keep well in cool storage, too. Cultivar 'Lotte' is medium-late ripening two weeks later than 'Victoria', and is partially self-fertile.

Average of three years, the highest soluble solids content was found for cultivar 'Adele' (13.28 Brix%), but cultivar 'Sonora' had the total content of acids (1.28 g 100 g^{-1}).

Significant changes in flesh firmness were observed at different storage times for cultivars 'Ance' and 'Lotte'. Significant variations in the total content of acids were determined for 'Ance'. Whereas cultivar 'Sonora' demonstrated substantial fluctuations in soluble solids content.

Correlations between firmness and soluble solids content were observed for cultivars 'Ance' (r=-0.731), 'Adele' (r=-0.436) and 'Sonora' (r=0.526). Cultivar 'Lotte' produced correlations between firmness and total content of acids (r=-0.536).

Significance of interaction was determined within cultivars, years, and years × cultivars.

Key words: *Prunus domestica* L., flesh firmness, total content of acids, soluble solids.

Introduction

Currently in the world the plum crop is about 10 million tons. However, over the last ten years *Prunus domestica* L. plantations in many parts of Europe fell sharply on account of virus disease PPV (*Plum Pox Virus*), and only in recent years after introduction of virus resistant cultivars the area again renewed (Ramming and Cociu, 1990; Hartmann et al., 2010). The harvest period of plums is from June to October. Plum fruits have rather rich biochemical content. By virtue of the natural fibre, especially valuable is their ability to cleanse the intestinal tract, improving digestion and peristalsis, which is the defense against arteriosclerosis, rheumatism and gout, as well as helps reduce blood cholesterol levels. Contributing to the excess of sodium salts and water clearance from the body, plums are a good tool for hypertension and the cardiovascular diseases, as well as to renal insufficiency. In the morning on an empty stomach to drink prune juice perfectly cleanses the body. Most of fresh fruit is water on average 84%, while dry matter is 16%, most of which are carbohydrates (Herrmann, 2001).

Plum biochemical composition is variable and differs between cultivars grown in Latvia and, for example, Germany. It depends on the solar intensity and day length. Of carbohydrates, plums mainly contain disaccharides (sucrose, which splits to monosaccharides as fructose and glucose) and polysaccharides (starch, cellulose, pectins). Pectins are partially soluble in water, but in concentrated sugar solution form a gel. Latvian-growing cultivars contain glucose, fructose and sucrose in relatively uniform quantities (2.7:2.1:2.8 g 100 g^{-1} of edible part) (Kaufmane et al., 2007), whereas in Germany K. Herrmann observed much higher levels of sucrose (on average, 7.3 g 100 g^{-1} of edible part), and less glucose (mean 2.3 g 100 g^{-1} of edible part) and fructose (0.94 g 100 g^{-1} of edible part). Most of the minerals found in plums are potassium (after German data - up to 300 mg 100 g^{-1} of edible part) and phosphorus (up to 26 mg 100 g^{-1} of edible part) (Herrmann, 2001). Plums also contain significant quantities of minerals Na, Mg, Ca, Fe, Cu, Cl, J, S, etc. (Кретович, 1986). In Russia (Moscow region), solids and total content of acids in local cultivars have been studied. On average, solids were 6.3 – 10.7 Brix%, emphasizing the importance of climatic conditions and soil properties. Sugar content in Russian cultivars was similar to that in Latvian cultivars, i.e. 2.5 – 9.5 g 100 g^{-1} of glucose; 1.0 – 4.5 g 100 g^{-1} of fructose and 0.6 – 7.0 g 100 g^{-1} sucrose. The total content of acids depended on the cultivar, and on average was from 0.16 to 1.32 g 100 g^{-1} (Анзин и др., 1956)

Organic acid content in fruits depends on the characteristics of the cultivar. Fluctuations in acid composition from 0.4 to 3.5 g 100 g^{-1} are mainly determined by climatic conditions and plant health. Russian researchers have looked for a relationship how the cultivar of pollination affects fruit quality (Кондратьев и др., 1971)

Vitamin C in Latvian plums maker up to 9.5 mg 100 g^{-1}, in German plums – up to 14 mg 100 g^{-1} of edible part. Plums contain quite a lot of vitamins - B_1, B_2, B_6, A, E and PP. Aroma compounds of plums are few and last for

a very short time. More aroma is found in acidic fruits of plums and prunes, especially in those which grow further north – if plums receive intense heat and solar light, they are sweeter, but less aromatic. Vitamin content in fruits strongly depends on the cultivar, the growing conditions, and the fruit maturity (if a plum is completely mellow, vitamin C is very low) (Kaufmane et al., 2007; Herrmann, 2001).

In the process of fruit ripening, the enzymes react with their substrates: starch is split down to glucose, which partially isomerizes into fructose, cellulose and pectin partially pull down, and the fruit becomes soft; chlorophyllases pull down chlorophyll, and immediately afterwards carotene and xanthophylls form the yellow ground colour. Later develop anthocyanins, which generate red colours in fruits (Baltess, 1998).

The aim of this study was to introduce with modifications of fruits' quality characteristics during storage of new Latvian cultivars.

Materials and Methods

The study was carried out at the Latvia State Institute of Fruit-Growing in Dobele, geographical position: East longitude 23°17.888`; North latitude 56°36.6333`. The plum trial was established in 1998 – 1999. The soil in the trial was sod-podzolic and carbonate with sandy clay loam, with organic matter content - 2.7%, soil reaction was slightly acidic (pH KCl – 6.1), with an average to low P content (96.4 mg kg^{-1}), average K content (278.1 mg kg^{-1}) and low Mg content (274 mg kg^{-1}). Soil analysis was conducted in 2010 by, Agrochemical Research Centre, Ltd. The trial was carried out with four perspective cultivars 'Ance', 'Adele', 'Sonora' and 'Lotte'. Three trees per each cultivar grafted on seedlings of *Prunus cerasifera* were planted at distance of 3 × 5 m.

The study was evaluating new domestic plum (*Prunus domestica* L.) selections, for which some fruit quality characteristics were studied in 2008 – 2010.

The study included measurements of some qualitative characteristics of the fruits immediately after harvesting, after one week, and after two weeks of storage in refrigerator (storage temperature + 3 ± 1 ºC, humidity 89 ± 2% RH). A total of 60 fruits were harvested at random at one time. Each measurement of week was carried out in 20 replications. Analysis included:

- the total content of acids (g 100 g^{-1}) (further in text TA) was determined by titrating with 0.1 N NaOH (Khan et al., 2008);
- firmness (kg cm^{-2}) of fruit – with a digital penetrometer (instrument error ± 0.01 g cm^{-2}) following the standard BS EN 12143 (July, 2001);
- soluble solids content (Brix%) of fresh fruits (further in text SSC) (ISO 2173: 2003) – at 20 °C with a digital refractometer ATAGO N20 (instrument error ± 0.01 Brix%) according to standard BS EN 12147 (July, 2001).

Estimation of the connection between the observed characteristics was done using analysis of variance (significance level α=0.05). Features of bilateral impact significance were determined by Pearson correlation. Differences between cultivars and replicate measurements were compared using descriptive statistics, and additional analysis of variance was done using Tukey test by which it is possible to group the results into significantly different groups, as designated by small letters of the alphabet ^{abcd}, in which ^{a} always means lowest value.

Results and Discussion

The requirements of fruit market are targeted mainly at a few individual characteristics: fruit colour (in Latvian market plums with yellow fruits have an especially good demand, unlike rest of Europe where the preferred are blue plums (prunes)), taste of fruit, and stone adherence from fruit flesh. For new plum cultivars, an essential trait is potentially higher fruit firmness that increases transportability and ensures longer consumption time. An assessment of disease resistance, tree vegetative characteristics, and fruit organoleptic rating (1 – 5 scale) were done before a qualitative evaluation of plum trial.

'Ance' – a cultivar of very early ripening time (first week of August). Fruits ripen about a month before 'Victoria' (a very popular cultivar grown in many orchards of the world). Self-sterile. The flavour varies between years, from good to very good. Fruit skin is thin, yellow with reddish blush. The suture line is inconspicuous. The stone is easily separated from flesh. The average yield from the year 2008 to 2010 was 43 kg per tree.

'Adele' – a cultivar of middle ripening time. Fruits ripen about a week before 'Victoria'. Self-sterile. Fruit skin is thin, yellow with reddish over-colour on part of fruit. Stone separation from flesh is good. Over colour is well pronounced, if the tree is trained to provide sunlight access into the canopy. The average yield from the year 2008 to 2010 was 20 kg per tree.

'Sonora' – a cultivar with an average of late ripening time. Fruits ripen about a week after 'Victoria'. Self-fertile. Fruitlets are self-thinning. The fruit skin is rather thin, with reddish ground colour and purple bloom. The suture line is semi-pronounced. Flavour is good. Stone separation from flesh at full maturity is good. The fruits are very attractive. The average yield from the year 2008 to 2010 was 25 kg per tree.

'Lotte' – a cultivar with late ripening time. Fruits ripen about two weeks after 'Victoria'. Flavour is very good and notably sweet. Fruit skin is rather thin, purplish blue with grayish blue bloom. Stone separation from flesh is semi good. The average yield from the 2008 to 2010 was 18 kg per tree.

For the first time, some of qualitative characteristics of the new cultivars were analyzed in 2008. Analyses were done for freshly harvested fruits, and then again after one and two weeks (in figures of measurement periods called – first, second, third time) (Fig. 1). In assessing the sustainability of fruit firmness (average of the three-year period) during storage, it was significantly stable for

cultivars `Adele` and` Sonora` – within a week firmness had not changed. Small firmness changes could be observed after two weeks. Significant and rapid changes in firmness occurred in cultivars 'Ance' and 'Lotte', which obviously will need earlier harvesting and marketing time. Although this reduces fruit eating quality, it is excusable for the total harvest time to be prolonged.

If the firmness fluctuations are small, the fruit shelf-life can be long enough. The more rapid are changes in firmness, the shorter the shelf-life period. A pronounced correlation of firmness and SSC was observed in cultivar 'Lotte' for which it is essential to harvest fruit at full maturity, or suffer a loss of taste. As other plum researchers have admitted, this increasingly proves the hypothesis that if determination of maturity of plums is inaccurate, fruit quality decreases and consumers desire to buy products diminishes (Vangdal et al., 2007; Crisosto and Kader, 2000). Long-time studies in Latvia on cultivars from Estonia, Lithuania, Russia and Sweden during 1999-2004 showed that fruit firmness ranged between 1.20 – 2.69 kg cm^{-2} (Kaufmane et al., 2010).

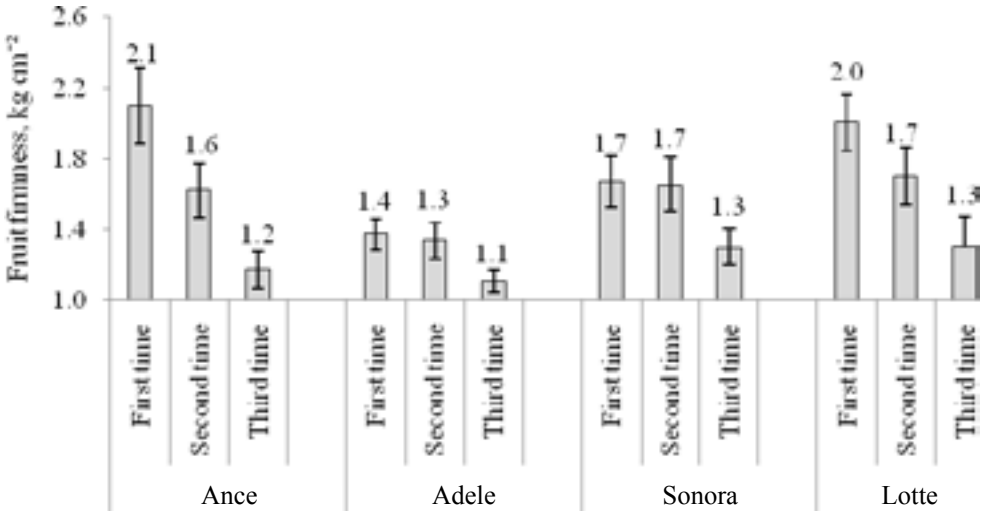


Figure 1. Changes in fruit firmness at different storage times.

During storage there were no significant differences in SSC between periods of measurement (Fig. 2) for cultivars 'Ance' and 'Adele', but during this time they had significant decrease in the TA (Fig. 3). Cultivar 'Sonora' had significant fluctuations in SSC between measurement periods. Currently there is no exact explanation as to why there have been such changes during all three years. To search for an explanation of this, we will continue to extend further studies about reduction of sugar in the period of fruit storage. SSC of the cultivar 'Lotte' changed, but these changes over the years didn't show significant differences.

The average SSC of the studied cultivars was 12.2 Brix%. Average SSC of Latvian growing *Prunus domestica* L. cultivars was found to be 15 – 17 Brix% (Kaufmane et al., 2010). From evaluated cultivars, the highest value of SSC was found in 'Ance' and 'Adele'. SSC of plum fruits determines their sweetness the higher the SSC, the sweeter the fruits.

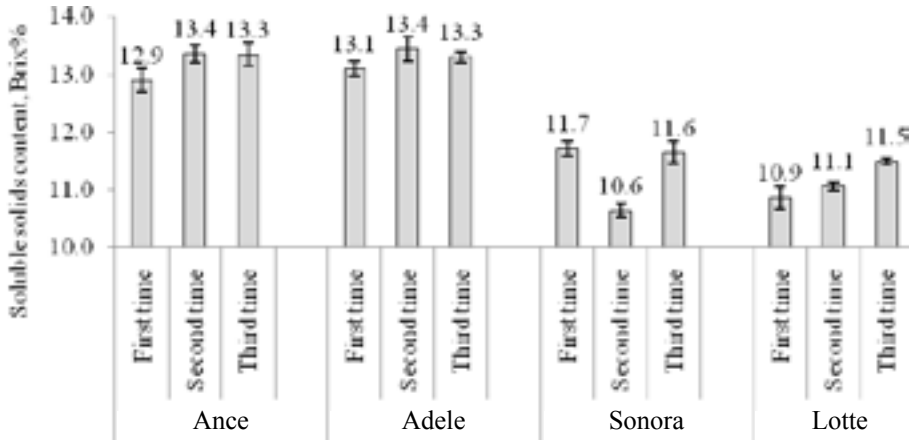


Figure 2. Changes in soluble solids content at different storage times.

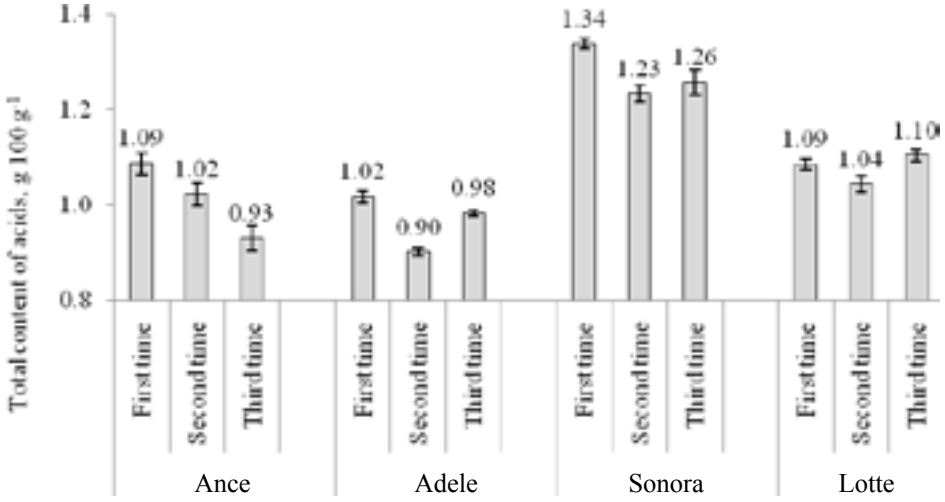


Figure 3. Changes in total content of acids at different storage times.

Evaluating the average difference between cultivars (Table 1), fruit firmness was significantly different for the cultivar 'Adele' it had softer fruit, while the other cultivars over the years didn`t show significant differences. The SSC was similar in cultivars 'Adele' and 'Ance' (on average 13.2 and 13.3 Brix% respectively), which was significantly higher than the other two analyzed cultivars. 'Sonora' had significantly different and higher TA content than other cultivars. The data can be compared with studies conducted in Dobele in 1990s, when SSC of cultivar 'Minjona' was 13.2 Brix%, but of 'Victoria' – 14.9 Brix%, whereas TA content was 1.34 and 1.48 g 100 g^{-1} respectively (Skrīvele et al., 1998). Average TA of other Latvian growing *Prunus domestica* L. research cultivars was found to be 1.15 – 2.11 g 100 g^{-1} (Kaufmane et al., 2010).

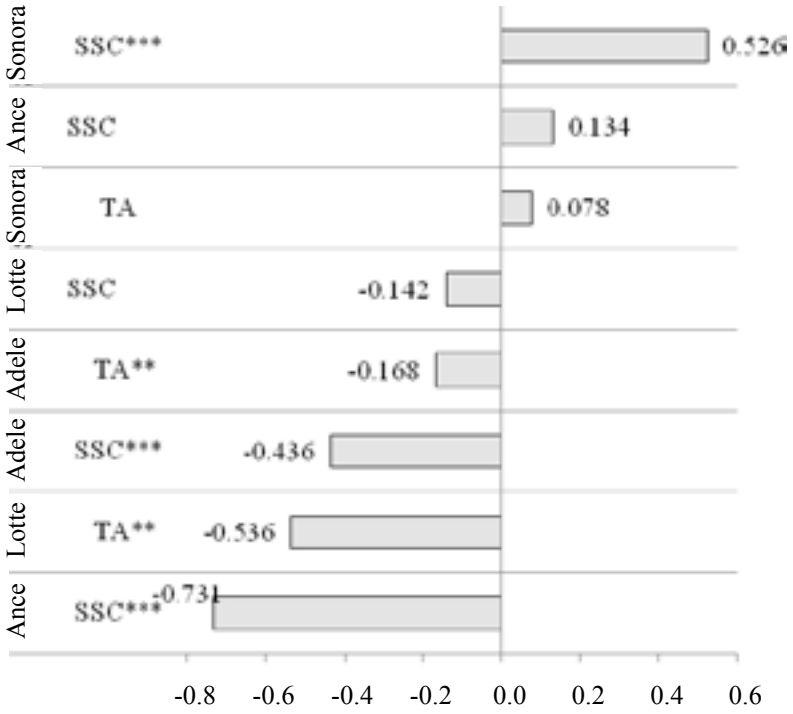
Table 1

Analysis of mean values of fruit quality characteristics using the Tukey criterion

Cultivar	Firmness, kg cm^{-2}	SSC, Brix%	TA, g 100 g^{-1}
'Adele'	1.27^{a}	13.28^{c}	0.97^{ab}
'Sonora'	1.54^{b}	11.34^{b}	1.28^{d}
'Ance'	1.63^{b}	13.20^{c}	1.01^{b}
'Lotte'	1.67^{b}	11.14^{a}	1.08^{bc}
p-value<0.001			

Cultivar 'Lotte' showed a medium negative correlation (r=-0.536). For these cultivars, as firmness decreased, also the content of TA increased.

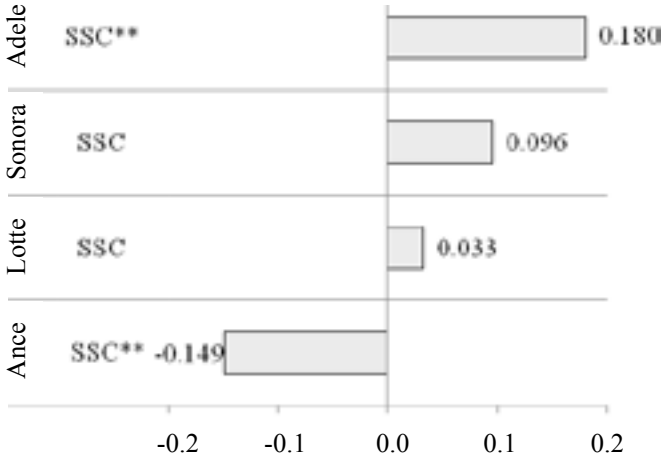
Fruit firmness showed a significant correlation ($p<0.001$) with SSC: for cultivar 'Sonora' – a medium positive correlation (r=0.526), for cultivar 'Adele' - a medium negative correlation (r=-0.436), for cultivar 'Ance' - a negative correlation (r=-0.731).



** p-value < 0.005; *** p-value < 0.001; r_{yx}; y – firmness

Figure 4. Correlation between soluble solids content (x), total content of acids (x), and fruit flesh firmness (y).

Cultivar 'Ance' had significant, but weak negative correlations between TA and SSC (Fig. 5) (r=-0.149); ($p<0.05$). Cultivars 'Sonora' and 'Lotte' did not show any significant correlations between TA and SSC.



**- p-value < 0.005; *** p-value < 0.001; r_{yx}; y – total content of acids

Figure 5. Correlation between soluble solids content and total content of acids.

After evaluating interactions between factors of research with $p<0.001$, significant effect on biochemical parameters was found for both factors (cultivars and year), which shows heterogeneity of the cultivars. Also for the interaction among these factors the effect was significant.

Conclusions

1. Fruit quality parameters varied between the years differently for different cultivars. For cultivars whose measurements were fluctuating, the reason could be non-uniform maturity of fruit samples (not for all

cultivars it is easy to visually estimate the same degree of maturity, especially for blue fruits). Results were better for cultivars whose degree of firmness was decreasing slower. The smallest changes in firmness showed cultivars 'Adele' and 'Sonora'. During the study period, these cultivars demonstrated a very good keeping quality, and density changes within two weeks were not significant. Fruits of cultivars 'Ance' and 'Lotte' consumable in shorter period - fruit qualitative characteristics diminished faster.

2. Both cultivars and years and the interaction between these factors showed a significant impact on the qualitative parameters of the new plum cultivars.
3. It is difficult to explain why there were fluctuations during the shelf-life in SSC for cultivar 'Sonora', and in TA for 'Adele'. After the single-factor variance analysis, they were significant: $p<0.05$.
4. Following the test results and their mathematical analysis it can be concluded that the time of fruit harvesting and storage life has very significant impact on plum fruit quality.

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References

1. Baltess V. (1998) *Pārtikas ķīmija* (*Food Chemistry).* Rīga, Latvijas Universitāte, 477 lpp. (in Latvian).
2. Crisosto C.H., Kader A.A. (2000) Plum and Fresh Prune Postharvest Quality Maintenance Guidelines. In: Hui Y.H. (eds) *Handbook of fruits and fruit processing*, Blackwell publishing, pp. 553-564.
3. Hartmann W., Neumüller M., Treutter D. (2010) Breeding for sharka resistance and high Fruit Quality in European plum (*Prunus domestica*) at Weihenstephan: breeding strategy and selection tools. In: Sottile F. (eds) *IX ISHS International Symposium on Plum and Prune genetics, breeding and pomology*, Dipartimento di Colture Aboree, University of Palermo, 20 p.
4. Herrmann K. (2001) *Inhaltsstoffe von Obst und Gemüse.(Ingredients of fruits and vegetables).* Stuttgart (Hohenheim), Ulmer, S. 200. (in German).
5. Kaufmane E., Skrivele M., Rubauskis E., Ikase L. (2007) The yield and fruit quality of two plum cultivars on different rootstocks. *Journal article*. *Sodininkyste ir Darzininkyste*, Lietuvos Sodininkystes ir Darzninkystes Institutas *Scientific works of the Lithuanian Institute of Horticulture*, 26 (3), pp.10-15.
6. Kaufmane E., Ikase L., Seglina D. (2010) Pomological Characteristics of Dessert Plum Cultivars in Latvia. In: Sottile F. (eds) *IX ISHS International Symposium on Plum and Prune genetics, breeding and pomology*, Dipartimento di Colture Aboree, University of Palermo, pp. 337-344.
7. Khan A.S., Singh Z., Abbasi1 N.A., Swinny E.E. (2008) Pre- or post-harvest applications of putrescine and low temperature storage affect fruit ripening and quality of 'Angelino' plum. *Journal of the Science of Food and Agriculture,* 88, pp. 1686-1695.
8. Ramming D.W., Cociu V. (1990) Plums. In: Moore J.N., Ballington J.R. (eds) *Genetic Resources of Temperate Fruit and Nut Crops*. First International Society for Horticulturae Science of Wageningen, the Netherlands, pp. 235-282.
9. Skrīvele M., Kaufmane E., Ikase L. (1998) `Lāse` and `Minjona` - two new, promising Latvian plum varieties. In: Ikase L. (eds) Fruit Growing Today and Tomorrow. *Proceeding of the International Scientific Conference dedicated to the 90th birthday of the breeder A.Spolītis and 100th birthday of the breeder V.Vārpa,* Dobele Horticultural Plant Breeding Experimental Station, Latvia, pp. 42-50.
10. Vangdal E., Flatland S., Nordbø R. (2007) Fruit quality changes during marketing of new plum cultivars (*Prunus domestica* L.). *Horticulturae science* (Prague), 34 (3), pp. 91-95.
11. Анзин Б.Н., Еникеев Х.К., Рожков М.И. (1956) *Слива (Plum)*. Москва, Колос, Russia, 460 с. (in Russian).
12. Кондратьев В.Д., Милованова Л.В., Семенченко С.Н. (1971) *Влияние опылителей на урожай сливы и качество плодов (Effect of pollination on yield and fruit quality of plums*). Кишинев, Бельцкая типография, Russia, 58 с. (in Russian).
13. Кретович В.Л. (1986) *Биохимия растений (Plant biochemistry)*. Москва, Высшая школа, Russia, 503 с. (in Russian).