Selected processing characteristics of new plum cultivars grown in the Czech Republic

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Abstract

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Fermentable sugars (the total of glucose, fructose, and sucrose), sorbitol content, dry matter content, and titrable acidity were monitored in fruits of 16 new plum cultivars from the harvests in 2004–2007. General linear model of two-factor grouping with testing of significance of simple contrasts with LSD method was used for statistical evaluation of plum cultivar chemical characteristics. Based on these results the tested cultivars were further divided into groups as regards their future processing into prunes, damson cheese or distillates. The traditional cultivar Italian Prune, grown in parallel, was used as the reference standard. Cultivars Gabrovská, Chrudimer, Elena, Hamanova, and President showed the best results and can be recommended for the production of distillates as well as prunes and damson cheese. Katinka, Anna Späth, and Veeblue are preferable for the production of distillates. Valjevka and Čačanska lepotica are suitable for processing into prunes and damson cheese. The substandard values of the parameters of concern were determined in Čačanska najbolja, Hanita, and Voyageur. Cultivars Bluefree, Stanley, and Valor were then valuated as the worst ones.

Keywords: plum cultivars; processing characteristics; dry matter content; fermentable sugars; sorbitol; titrable acidity; prunes; damson cheese; distillates

In the first half of the last century, plums were one of the most widespread fruit crops in former Czechoslovakia. They represented approximately 25% of fruit trees according to statistics from 1975 (Anonymous 1976). Since the 1980s, the cultivation of plums has decreased sharply (by circa 60%). It was due to the sharka (*Plum pox virus*) spread. Most of the plum cultivars grown at that time (namely high-quality Italian Prune) were susceptible to this disease. Currently, there is a new development of plum growing in the Czech Republic. The mean annual yield of plums over the past 5 years was 5,000 t. From this amount, 1,300 t was aimed for processing industry (Buchtová 2007). In the last years, there has been a growing demand for new, nutritionally valuable cultivars resistant to sharka. These cultivars should also be suitable for direct consumption and processing.

In the Czech Republic the main traditional plum products include prunes, damson cheese, and distillates (plum brandy). In addition to the economical and fruit characteristics (yield, weight, shape and colour of fruit, weight and separability of stone, skin firmness, resistance to diseases, etc.), the chemicals parameters of the fruit (contents of dry matter, saccharides and polyols), play impor-

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tant roles in the commercial use of plums. The saccharides present in plums include particularly free mono- and disaccharides (glucose, fructose, and sucrose) and alcoholic sugars, sorbitol for the most part (Wrolstad, Shallenberger 1981).

As regards the content of fermentable sugars (the total content of glucose, fructose, and sucrose), their level predicts the yield of ethanol that can be obtained by fermentation in the production of distillates. Of course, the level of aromatic substances in the fruit is another critical factor for providing the final product with its required specific aroma. It is in compliance with the findings of Jung (2001), published in his study on the optimization of distillate production from plums. The value of titrable acidity may be added for information, as it may indicate necessary pH adjustment before fermentation (pH 3 is usually used). The content of sorbitol that is not fermentable has no effect on alcohol production.

However, sorbitol has beneficial effects on those plum processes that involve long periods of thermal processing, such as drying and damson cheese production. Due to its low liability to caramelisation and non-enzymatic Maillard reactions, sorbitol protects the products from excessive browning and undesirable changes of taste (Wilford et al. 1997). It also features the ability to absorb water (being so-called „humectant") and to maintain suppleness of final products, without affecting their water activity (a_w) (Zimmermann 1989; Forni et al. 1992). In terms of production economy it is also helpful to take into account the content of dry matter of plums in case the fruit is to be subject of thermal processing. The plums of lower dry matter values have higher demands on energy required for water evaporation in raw material drying or thickening.

In the past, various methods were used for determining the content of free sugars and sorbitol in fruits and fruit products, including chemical and enzymatic procedures, TLC, gas chromatography and so on (Wrolstad, Shallenberger et al. 1981). At present, modern chromatographic methods, such as high performance liquid chromatography (HPLC) with refractometric detection (Smith et al. 1986; Forni et al. 1992; Wilford et al. 1997) and high performance anion-exchange chromatography (HPAEC) with pulsed amperometric detection (Cataldi et al. 1998) are widely used for the purpose.

This work was aimed at the determination of the above chemical parameters of 16 new plum cultivars, tested in the Research and Breeding Institute of Pomology Holovousy, Ltd., for their resistance against *Plum pox virus* (PPV) during the harvests 2004–2007. The results were subjected to statistical processing and used as the basis for the evaluation of new plum cultivars as to their suitability for subsequent processing into prunes, damson cheese and distillates. The traditional cultivar Italian Prune, grown in parallel, was used as the reference standard.

MATERIAL AND METHODS

Plum cultivar samples: Italian Prune, Hamanova, Gabrovská, Chrudimer, Valjevka, Bluefree, Čačanska lepotica, Čačanska najbolja, Hanita, Stanley, Valor, Anna Späth, Elena, President, Katinka, Veeblue, and Voyageur. The samples from the harvests of 2004 to 2007 were obtained from the Research and Breeding Institute of Pomology Holovousy, Ltd., Czech Republic. The fruits were harvested at commercial maturity from PPV-free trees. The presence of PPV in selected trees was tested by ELISA (Enzyme-Linked Immuno Sorbent Assay).

Determination of fermentable sugars (total of glucose, fructose, and sucrose) and sorbitol contents (% w./w.)

a) Preparation of plum cultivar homogenate
The sample of plums (5 kg approximately) was stoned and thoroughly crushed in an electric mixer. The portion of 500 g was withdrawn and further processed in the Ultraturax homogeniser.

b) Sample preparation for analysis
Homogenate (10.0 g) was weighed in a flask and demineralised water (100 ml) was added. The flask was put in an ultrasonic bath for 20 min and then into an agitated water bath heated to the temperature of 50°C for additional 30 min. Water extract was obtained by centrifugation of the mixture at 20,000 rpm (15 min) and supernatant filtered using 0.45 μm membrzane filter. The final filtrate was used directly as the HPLC column feed.

c) HPLC analysis with refractometric detection
Waters instrument: pump 515, column thermostat, in-line degasser AF, autosampler 717 plus, RI detector 2414.
Column: Watrex Ostion LGKS 0800 Ca form, 250 × 8 mm; pre-column: Watrex HEMA BIO SB+Q; temperature: 80°C; injection: 20 μl of sample; flow rate: 0.5 ml demin. water/min.

Table 1. Multiple range analysis of fermentable sugars in plum cultivars (Method: 95 % LSD)

Cultivar	Count	LS Mean	Homogeneous Groups
Valor	4	7.150	x
Čačanska lepotica	3	8.895	x
Bluefree	4	8.950	x
Stanley	3	8.975	x
Hanita	3	9.242	xx
Valjevka	3	9.332	xx
Voyageur	4	9.550	xx
Čačanska najbolja	4	9.600	xx
President	3	10.031	xx
Veeblue	3	10.095	xxx
Hamanova	3	10.265	xxxx
Chrudimer	3	10.999	xxx
Gabrovská	3	11.028	xxx
Elena	3	11.099	xx
Anna Späth	3	11.197	xx
Katinka	3	11.328	x
Italian Prune	3	12.509	x

Glucose, fructose, sucrose, and sorbitol standard solutions were used for calibration curve plotting. The results were processed using CSW 32 software.

Uncertainty of measurement was expressed as a confidence interval at the significance level of 0.95 for 6 parallel measurements: sucrose and glucose: ± 0.1% w./w.; fructose and sorbitol: ± 0.05% w./w. Detection limit: 0.01% w./w. for all the saccharides.

Dry matter content (% w./w.): was determined by drying the samples in a vacuum drying oven at the pressure of 13.3 kPa and temperature of 70°C to the constant weight.

Titrable acidity: the mixture of homogenised plum flesh (10.0 g) and 200.0 ml demineralised water was titrated with 0.1N NaOH solution to the value of pH 8.5. The results were converted into the content of malic acid (g/kg).

Statistical analysis of the results: Relationship among the analysed chemical characteristic levels of selected plum cultivars in observed years was expressed by general linear model of two-factor grouping with one observation in subgroup (Scheffé 1958; Rao 1978). Statistically significant differences for plum cultivars were identified by the LSD method (Likeš 1968; Rao 1978). The same method was used for construction of 95% confidence intervals of analysed substance contents. The statistical evaluation was realised by Statgraphics 7 and Statistica 6 softwares.

RESULTS AND DISCUSSION

Both fermentable sugars content and sorbitol content were monitored by HPLC method with refractometric detection in fruits of 17 plum cultivars from the harvests 2004–2007. The values of dry matter content and titrable acidity were determined in addition. Data files comprising the analytic results obtained from three harvests, at least, were then created and statistically evaluated. Both the point estimator and 95% interval estimators of mean values of plum cultivar chemical characteristics are depicted in Figs. 1–4.

Table 2. Multiple range analysis of sorbitol content in plum cultivars (Method: 95 % LSD)

Cultivar	Count	LS Mean	Homogeneous Groups
Italian Prune	3	2.975	x
Chrudimer	3	2.078	x
Gabrovská	3	1.863	xx
President	3	1.810	xx
Valjevka	3	1.475	xx
Elena	3	1.412	xxx
Hamanova	3	1.328	xxx
Čačanska lepotica	3	1.207	xxx
Hanita	3	0.941	xxxx
Anna Späth	3	0.904	xxxx
Voyageur	4	0.783	xxx
Valor	4	0.605	xxx
Čačanska najbolja	4	0.583	xxx
Bluefree	4	0.563	xxx
Veeblue	3	0.425	xxx
Stanley	3	0.398	xx
Katinka	3	0.068	x

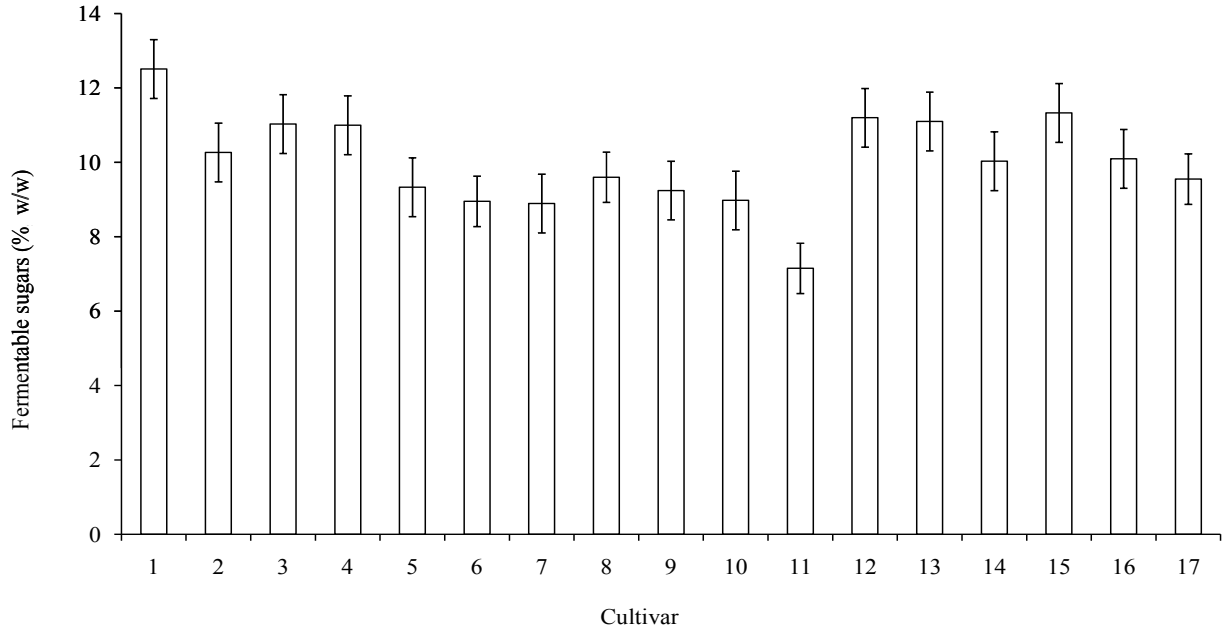

Fig. 1. Statistical evaluation of the mean fermentable sugar content in plum cultivars
1 – Italian Prune, 2 – Hamanova, 3 – Gabrovská, 4 – Chrudimer, 5 – Valjevka, 6 – Bluefree, 7 – Čačanska lepotica, 8 – Čačanska najbolja, 9 – Hanita, 10 – Stanley, 11 – Valor, 12 – Anna Späth, 13 – Elena, 14 – President, 15 – Katinka, 16 – Veeblue, 17 – Voyageur

According to statistical analysis, it is possible to divide investigated varieties into several homogeneous groups with analogous chemical characteristics (see Tabs. 1–4). These groups are constructed relatively to particular variety. It is real that these groups overlap. Factual division, stated below, respects varieties classification given by homogenous groups and further, practical usage of such division is aimed. The highest and statistically significantly different values of all the tested parameters, were found with

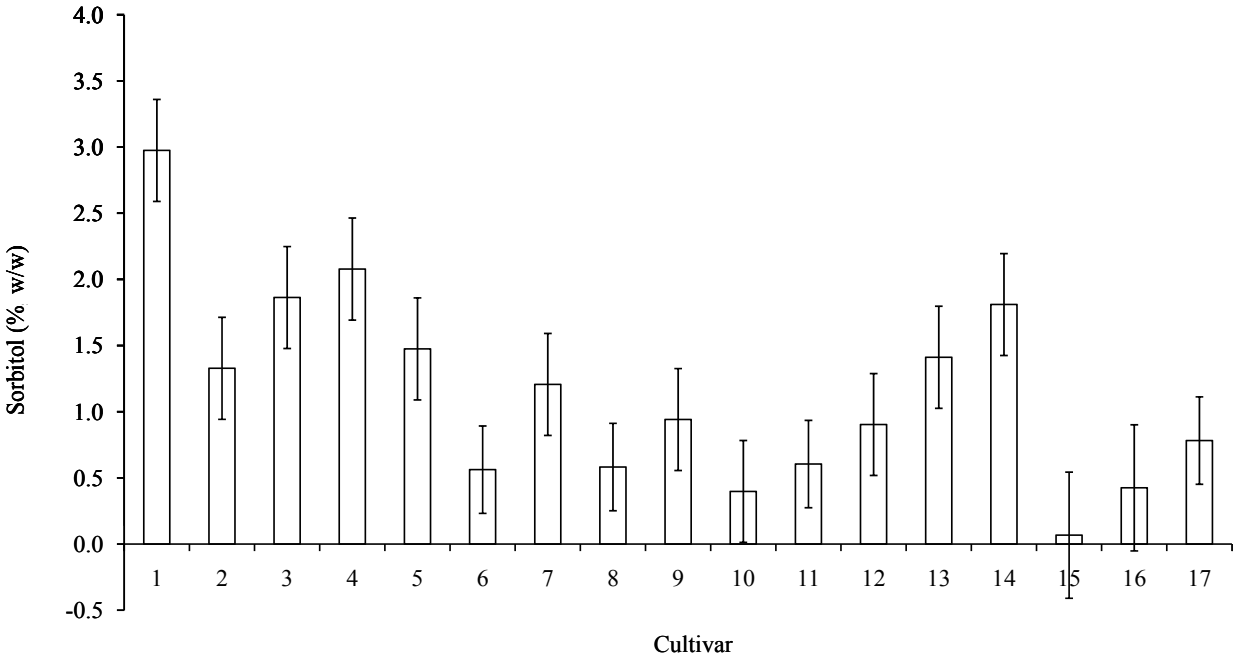

Fig. 2. Statistical evaluation of the mean sorbitol content in plum cultivars
For identification of cultivars see Fig. 1.

Table 3. Multiple range analysis of dry matter content in plum cultivars (Method: 95 % LSD)

Cultivar	Count	LS Mean	Homogeneous Groups
Italian Prune	3	20.543	x
Chrudimer	3	16.787	x
Gabrovská	3	16.752	x
Elena	3	16.487	x
Anna Späth	3	16.327	xx
President	3	16.194	xx
Hamanova	3	15.387	xxx
Katinka	3	15.209	xxx
Valjevka	3	14.787	xxx
Veeblue	3	14.718	xxx
Bluefree	4	14.400	xx
Čačanska najbolja	4	14.350	xx
Hanita	3	14.234	xx
Čačanska lepotica	3	14.152	xx
Voyageur	4	13.700	x
Valor	4	13.625	x
Stanley	3	13.467	x

the Italian Prune (reference standard). Other tested plum cultivars can be characterised as follows.

In the group featuring the high contents of fermentable sugars no statistically significant difference was found among cultivars Anna Späth, Gabrovská, Elena, Chrudimer, Katinka, and Hamanova. Other large group of cultivars characterised by their medium contents of fermentable sugars, included Veeblue, President, Voyageur, Čačanska najbolja, Valjevka, and Hanita. Cultivars Stanley, Bluefree, and Čačanska lepotica were classified in the third group with a low fermentable sugar level. Valor was found to be the cultivar showing the lowest and significantly different content of fermentable sugars.

Regarding sorbitol, the cultivars could be divided into the following groups of statistically insignificant differences. The highest sorbitol contents were found in the cultivar group consisting of Chrudimer, Gabrovská, and President, followed by the group including Valjevka, Elena, Hamanova, Čačanska lepotica, and Hanita. The largest group with lower sorbitol contents comprised cultivars Anna Späth, Voyageur, Valor, Čačanska najbolja, Bluefree, Veeblue, and Stanley. Cultivar Katinka showed a very low sorbitol content, significantly different from that of other groups.

Based on the dry matter content, tested cultivars could be divided into two different groups. The first of them, comprising Chrudimer, Gabrovská, Elena, Anna Späth, President, Hamanova, Katinka, Valjevka, and Veeblue, featured higher contents of dry matter; the other group of lower dry matter values consisted of Bluefree, Čačanska najbolja, Hanita, Čačanska lepotica, Voyageur, Valor, and Stanley.

At the same time, the evaluation of individual cultivars is given here according to the indicative parameter of titrable acidity. The highest and statistically significant differences of values were found in cultivars Hanita, Valor, Bluefree, and Hamanova. According to the decreasing acidity values the group comprising Čačanska lepotica, President, Voyageur, and Chrudimer and other group consisting of Čačanska najbolja, Valjevka, Gabrovská, and Stanley were created. The last group featuring the lowest and statistically insignificant acidity differences included the cultivars Veeblue, Elena, Anna Späth, and Katinka.

Table 4. Multiple range analysis of titrable acidity in plum cultivars (Method: 95 % LSD)

Cultivar	Count	LS Mean	Homogeneous Groups
Hanita	3	20.404	x
Valor	4	17.438	x
Bluefree	4	15.038	x
Hamanova	3	13.998	xx
Čačanska lepotica	3	13.096	xx
President	3	12.585	xx
Voyageur	4	12.163	xx
Chrudimer	3	11.664	xxx
Čačanska najbolja	4	10.875	xxx
Valjevka	3	10.731	xxx
Gabrovská	3	10.080	xxx
Stanley	3	9.771	xx
Italian Prune	3	8.444	xx
Veeblue	3	8.273	xx
Elena	3	8.114	x
Anna Späth	3	7.819	x
Katinka	3	7.566	x

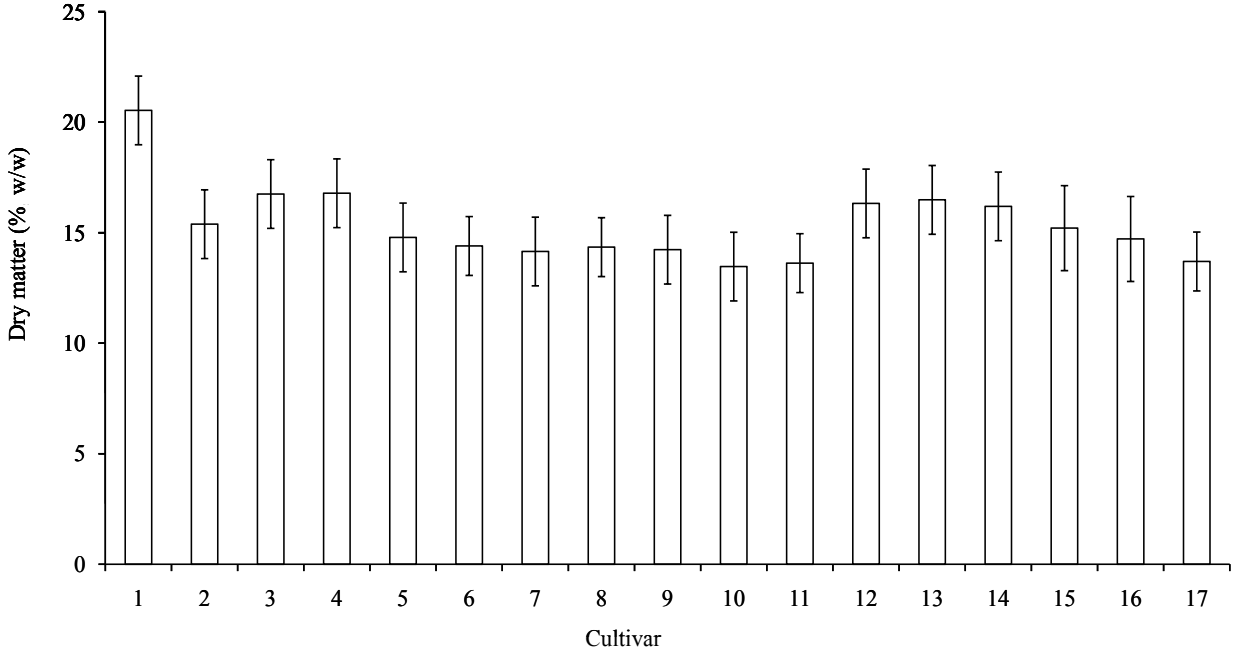

Fig. 3. Statistical evaluation of the mean dry matter content in plum cultivars
For identification of cultivars see Fig. 1.

In conclusion, based on the above-mentioned results, the newly tested plum cultivars were completely evaluated as to their suitability for further processing into prunes, damson cheese and distillates. In this case both the statistically processed mean chemical parameters and the homogeneity within the group were compared to the corresponding results obtained for the reference cultivar Italian Prune. As expected, the latter can be evaluated as the best one in terms of the future fruit processing, as its mean chemical parameters (fermentable sugars 12.5%, sorbitol 2.98% and dry matter con-

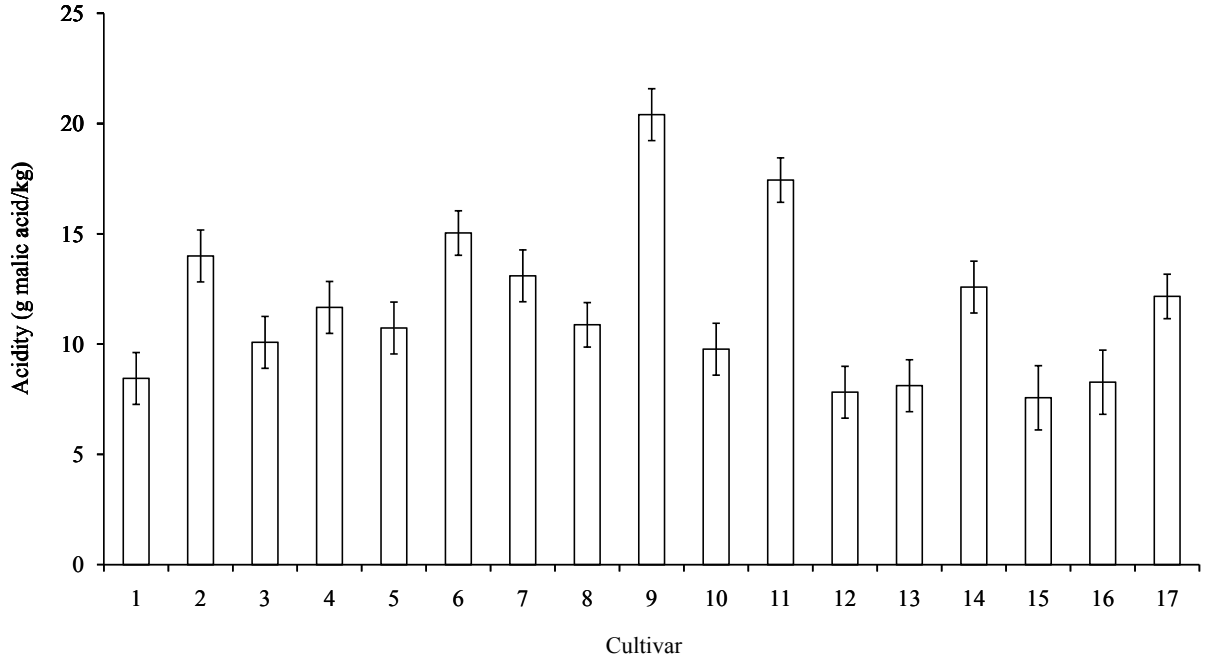

Fig. 4. Statistical evaluation of the mean titrable acidity in plum cultivars
For identification of cultivars see Fig. 1.

tent 20.5%) achieve the highest levels observed and show statistically significant differences compared to any other cultivars of the set. As to other cultivars, the results of Gabrovská and Chrudimer were nearest to those of Italian Prune (fermentable sugars 11.0%, sorbitol 1.86–2.08%, and dry matter 15.4–16.5%). Good general results are reported for Hamanova, Elena, and President (range of mean values: fermentable sugars 10.0–11.1%; sorbitol 1.33–1.81%; dry matter content 15.4–16.5%). All these cultivars may be recommended for the production of distillates as well as prunes and damson cheese, because of their favourable contents of fermentable sugars, sorbitol, and dry matter. Due to their high values of fermentable sugars (10.1–11.3%) and low levels of sorbitol (0.07–0.90%) the cultivars Katinka, Anna Späth, and Veeblue may be recommended for plum distillate production. On the other hand, Valjevka and Čačanska lepotica featuring high sorbitol (1.2–1.5%) and dry matter (14.2–14.8%) contents appear suitable for prunes and damson cheese production. Mediocre results only were obtained with Čačanska najbolja, Hanita, and Voyageur (fermentable sugars 9.2–9.6%; sorbitol 0.58–0.94%, dry matter content 13.7–14.4%). The remaining cultivars, namely Bluefree, Stanley, and Valor, were evaluated as the worst ones. Their chemical parameters, particularly the low contents of fermentable sugars (7.2–9.0%) and sorbitol (0.40–0.61%) were substantially lower than at other cultivars.

In conclusion, we should remark that, in addition to the above evaluation of plum cultivars based on chemical parameters, there are other factors influencing their processing use (sensory properties, economical and growing aspects, and so on). However, similar processing characteristics assessment of plum cultivars grown in the Czech Republic was not realised up to now. The reason is that the detailed sugar composition of plums was not available.

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