ORIGINAL SCIENTIFIC PAPER

Influence of Processing on Yield and Quality of Cloudy Plum Juices

Branka Levaj*, Nada Vahčić, Verica Dragović-Uzelac, Sanela Svetličić, Vanja Sabljak, Korina Herceg, Dragana Stanić, Džoni Marinčić, Ivona Elez, Danijela Bursać Kovačević, Sanja Lončarić

Faculty of Food Technology and Biotechnology, University of Zagreb, Pierottijeva 6, 10000 Zagreb, Croatia

Summary

Pressing of plum fruit in producing cloudy juices is difficult due to high amount of pectic substances in plum. Maceration of pulp with enzymes is usual way to make pressing more effective but provided that no negative impact on juice quality and biological value e.g. antioxidant capacity (AC). Content of anthocyanins and other phenolic compounds in juices are related with its AC so better extraction of these compounds from fruit to juice is of great importance to obtain juice with nice colour, health benefits and excellent sensory characteristics. The aim of this work was to investigate the influence of enzyme concentration, maceration temperature and duration on the yield, content of phenolic compounds, anthocyanins, AC and sensory perception in producing cloudy juices. Plum fruit (Prunus domestica L.), cultivar Bistrica, was used to produce cloudy juices on small scale equipment. Before pressing, fruits were pitted and treated with maceration enzymes in concentration of 100 or 140 ppm at 20 or 48°C for one or two hours (eight samples). Anthocyanins were determined by method based on bisulfite bleaching, total phenolics (TP) by Folin-Ciocalteu reagent, the AC by FRAP (Ferric Reducing Antioxidant Power) method and sensory evaluation by Quantitative descriptive method. The higher yields were obtained with pre-treatments by 140 ppm of enzyme on 48°C during 1 and 2h, and also in the same juices the highest amount of TP was found. In general, anthocyanin contents increased with enzyme concentration, temperature and duration. Despite some exceptions increasing trend of AC with enzyme concentration and temperature of treatment was observed. Sensory all juices were high evaluated without significant differences. Enzyme treatment on 48°C/2h could be recommended to produce high quality cloudy plum juice due to high yield, high anthocyanin contents and total phenolics, antioxidant capacity and sensory evaluation.

Keywords: plum juice, enzyme treatment, sensory evaluation, phenolics

Introduction

Juices are economically very important fruit products. On the market citrus juices are the most popular following by apple juice, but plum juices are very rare. In Croatia the demand for fresh squeezed fruit juices by consumers constantly increases and domestic fruit are especially appreciated. Traditionally growing plum in Croatia are very popular and large quantities of produced plums are used for both consumption of fresh and processing, but very small quantities are processed into juices.

According to applied technology three main groups of juices is known: clear, cloudy and pulpy juices. Processes of juice separation from fruit cell are different due to type of juice and for the first two juices are usually obtained by pressing. All fruits are not suitable for all type of juices, *e.g.* fruit with the pigments insoluble in water is not suitable for producing clear juices. Red colour of plum skin origin from anthocyanins, pigment soluble in water, so plum fruit is suitable for all type of juices (Lovrić, 1984). In some plum cultivars *e.g.* Bistrica anthocyanins are located only within the thin skin of the fruits so process should be optimized to obtain nice red coloured juice. Many authors studied usage of pectolitic enzymes in juice production concern to better yield and colour extraction *e.g.* Chang *et al.*(1994) and Will and Dietrich (2006) in plum juices, Landbo and Meyer (2004) and Pap *et al.*(2010) in black current juices, and Landbo *et al.* (2007) in elderberry juices. Its effectiveness depends on type of applied enzyme and treatment conditions (pectinolytic enzyme dose, maceration duration, and reaction temperature). Purpose of pectinolytic enzymes addition is degradation of protopectin and partly pectins from primary cell wall and middle lamella (Kashyap et al., 2001) and this process is responsible for relase of juice from the cells as well as the pigments from the plum skin cells (Will and Dietrich, 2006). Pectin should not be degraded completely because it stabilizes the cloudiness in cloudy juice. Furthermore, plums contain high amounts of other polyphenols besides the anthocyanins (Donovan *et al*., 1998, Fang *et al*., 2002, Kim *et al*., 2003a, 2003b, Walkowiak-Tomczak *et al*., 2008). So maceration process should be optimized to maintain and possibly to increase anthocyanins and other polyphenols content in juice (Will and Dietrich, 2006). Polyphenolic compounds have high antioxidant capacity (Will and Dietrich, 2006) and many studies have shown their health-promoting properties (Chong *et al*., 2010, Hooshmand and Arjmandi, 2009, Thomasset *et al*., 2006).

The aim of the present work was to develop optimal pretreatment conditions in order to obtain better yield and better coloured cloudy juice with high antioxidant capacity and good sensory properties.

Materials and Methods

Plum fruit (*Prunus domestica* L.), cultivar Bistrica, were purchased on the local market, and frozen till juice manufacturing. After defrosting it was used to produce cloudy juices on small scale equipment according to scheme (Figure 1). Fruits (2 kg) were pitted, chopped and treated with 100 or 140 ppm maceration enzymes (Endozym Pectofruit PR, AEB group, Italy) at 20 or 48 °C for one or two hours (eight samples). These concentrations and temperatures were selected according to the manufacturer's instructions. Pressing was done on hydraulic press (Euclid Ltd., Croatia). After pressing juice was filled in glass bottles of 200 mL and closed. Pasteurization of juices was done after filling the bottles at 80°C/10 min. Cooling was done by immersing of the pasteurized bottles in cold water (Fig. 1).

The list of all enzyme treatment and code of samples is presented in Table 1. Juices were kept in refrigeration at 8°C until analysis.

Corresponding author: blevaj@pbf.hr

Table 1. *Conditions of enzyme pretreatment and the code of produced juices*

Code of sample	Temperature (°C)	Concentration of enzym (ppm)	Duration (h)
20/100/1	20	100	1
20/140/1	20	140	1
20/100/2	20	100	2
20/140/2	20	140	2
48/100/1	48	100	1
48/140/1	48	140	1
48/100/2	48	100	2
48/140/2	48	140	2

Yields were calculated on fruit pulp, after pitting.

Total acidity (expressed as g malic acid/100 mL juice) and pH-value were determined in accordance with Tanner and Brunner (1979). Soluble solids were determined by measuring the °Brix (Atago refractometer, Tokyo, Japan). Pulp ratio was determined according the IFU method (IFU, 1991)

The anthocyanins in juices were determined by method based on bisulfite bleaching (Ough and Amerine, 1988). Total phenolics (TP) were extracted according to Coseteng and Lee (1987) and determined by spectrofotometer using Folin-Ciocalteu reagent (Ough and Amerine, 1988) based on galic acid calibration so results are presented as equivalent of galic acid (GAE). The antioxidant capacity was determined by FRAP method (Connor *et al*, 2002) and expressed as mmol Trolox equvalent (TE) per liter.

All analysis were done in triplicate and data are presented as mean value.

Obtained juices were submitted to sensory evaluation by Quantitative descriptive analysis which was very comprehensive. The panelists were requested to list the terms appropriate to describe the colour, odour, taste, consistency and overall sensory impression whereas a total of 10 descriptive terms for all major sensory attribute categories were generated, but in this paper only all overall sensory impression of potability is presented. The panelists scored the samples using a suitable line intensity scale, with scores awarded on a scale of 0 – 9 in which 9 indicated the best impression. Sensory analysis was carried out by a trained panel consisted of ten to fifteen members per session. The procedure was performed according to ISO 6564, ISO 8587 and ISO 11036 (in a sensory laboratory equipped according to ISO 8589) and (Bursać *et al*., 2007; Bursać Kovačević *et al*., 2008).

Statistical data analysis

Statistical analysis was performed via analysis of variance (ANOVA) using Statistica v. 9 (Statsoft Inc, Tulsa, OK, USA) in order to investigate influence of pre-treatment (enzyme concentration, maceration duration and temperature) on each determined parameter. Differences were considered significant at $p \leq 0.05$.

Results and discussion

Better liquefaction was obtained in all samples treated at 48 °C than at 20 °C, and the yields were in the range 78 – 83 % and 58 – 71 % (Fig. 2), respectively. The obtained results at 48 °C are in accordance with literature data of Chang *et al.* (1994). who investigated the influence of enzyme treatment at 49°C/3h on plum juices from different cultivars and yield was in range 79.48 – 84.70 % depending on cultivar. In present work, it seems that temperature has greater impact on yield than enzyme concentration. Duration has greater impact only if pretreatment was at 20 °C. According to ANOVA only temperature had significant influence on yield ($p \leq 0.05$) (table 4a).

Soluble solids (Table 2) in obtained juices were in the range 15.1– 16.5 °Brix what is in accordance with Chang *et al.* (1994) results, 11.1 – 18.9 °Brix depending on cultivar, and lower than in three cultivars investigated by Will and Dietrich (2006) (19.73 – 21.36 °Brix). In present study all juices were produced from one cultivar but with different pretreatment. According to obtained results juices pretreated

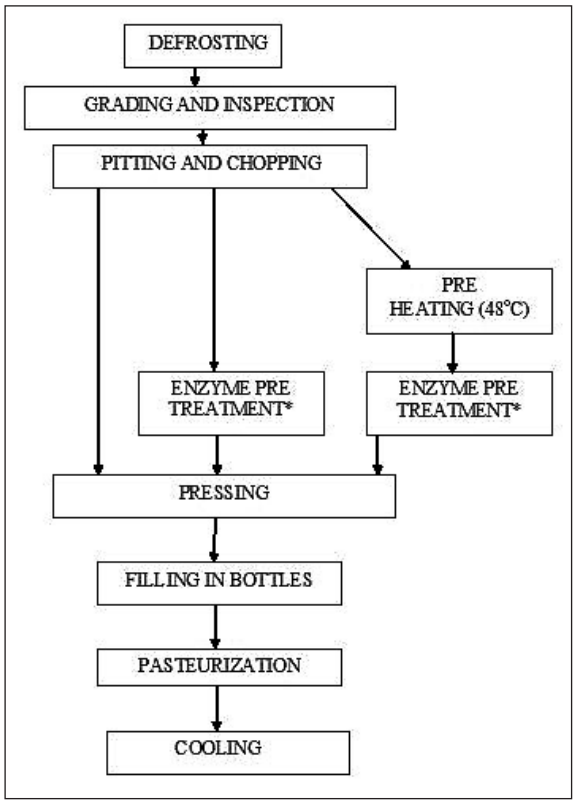

Figure 1. *Scheme of juice producing*

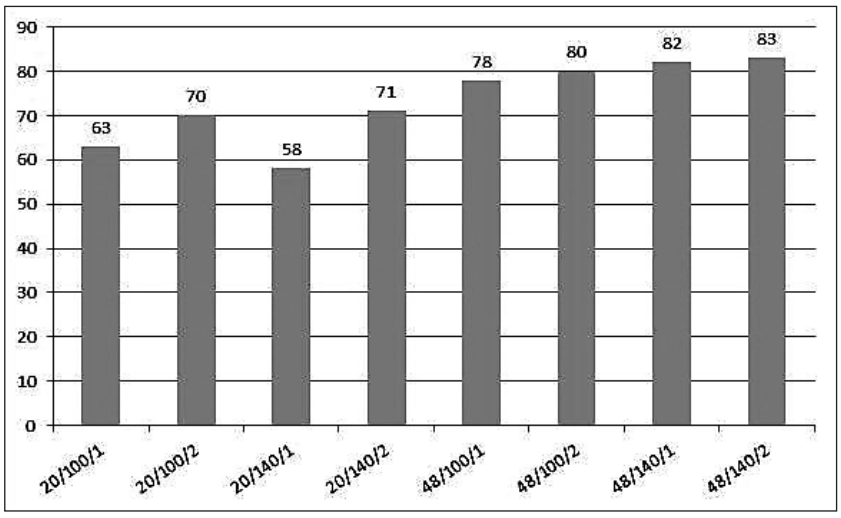

Figure 2. *Yield (%) calculated on pulp (pitted)*

at 48 °C had higher content of soluble solids than the others. Further, the lower total acidity (Table 2) was determined in the samples pretreated at 48 °C (0.64 – 0.72 mg/100 mL) than ones pre-treated at 20 °C (0.74 – 0.79 mg/100 mL). According to ANOVA ($p \leq 0.05$) it was observed that the temperature of pretreatment significantly influenced on content of soluble solids and total acidity (Table 4a). Results obtained for total acidity was lower than Chang *et al.* (1994) determined (1.10 - 1.83 %) and in the range of Will and Dietrich (2006) results (6.6 – 11.2 mg/L). Chang *et al.* (1994) studied only influence at 49 °C and Will and Dietrich (2006) at 50 °C on different cultivars, so they did not compare effect of different temperature. Total acidity could be dependent on cultivar, and probably it is the cause of difference between our results and results of Chang *et al.* (1994). Pretreatment had no influence on pH value (Table 2) which was in range 3.65-3.79 in all samples what is a little bit higher than measured pH values of Will and Dietrich (2006) (3.36 – 3.53). Remarkable high °Brix/Acid ratio was determined in all samples (19.4 – 25.7) especially in samples treated at 48 °C (22.8 – 25.7) and much higher than in cultivars Chang *et al.* (1994) investigated (6.09 – 15.18). Higher ratio means more acceptable juice (Fellers *et al.*, 1988, Chang *et al.*, 1994). The highest impact of pretreatment on pulp ratio was observed. Juices treated at 20 °C were very viscous and settling in given conditions was difficult.

Table 2. *Physico – chemical parameters of juices*

Code of juice	Soluble solids (°Brix)	pH	Total acidity g mallic acid/ 100 mL	°Brix/ acid ratio	Pulp ratio
20/100/1	15.1	3.66	0.78	19.4	2.3
20/100/2	15.4	3.68	0.79	20.5	5.6
20/140/1	15.2	3.77	0.75	20.3	4.2
20/140/2	15.5	3.77	0.74	21.0	9.0
48/100/1	16.5	3.65	0.72	22.8	0.02
48/100/2	16.5	3.79	0.64	25.7	0.02
48/140/1	16.4	3.69	0.67	24.5	0.02
48/140/2	16.5	3.70	0.70	23.7	0.03

Table 3. *Total phenolics, anthocyanins, and antioxidant capacity of juices*

Code of juice	Total phenolics (mg GAE/L)	Total anthocyanins (mg/L)	Antioxidant capacity (mmol TE/L)
20/100/1	329.1	59.0	1.608
20/100/2	350.4	83.0	4.466
20/140/1	888.9	70.1	3.27
20/140/2	692.3	106.4	3.449
48/100/1	683.7	65.8	3.819
48/100/2	470.1	91.0	3.72
48/140/1	2700.8	67.0	4.475
48/140/2	2927.3	127.3	4.081

Approximately 8 times higher amount of total phenolics (Table 3) was found in the juices 48/140/1 and 48/140/2 in comparisom with juice 20/100/1. Such high values are in accordance with previously reported values (Will and Dietrich, 2006, Chang et al., 1994, Rop et al. 2009). There were some discrepancies in results of total phenolics but, in general, it seems that higher enzyme concentration and higher temperature resulted with increase of concentration of total phenolics. But according to ANOVA ($p \leq 0.05$) there is no significant influence (table 4). Anthocyanin contents (Table 3) increased with enzyme concentration, duration and temperature (exception juice 48/140/1 – 67 mg/L versus juice 20/140/1 – 70 mg/L). It seems that duration and enzyme concentration had more impact on anthocyanin content than temperature. According to ANOVA ($p \leq 0.05$) that the duration of enzyme treatment significantly influenced on anthocyanin concentration (Table 4b). Chang et al. (1995) concluded that pectinases (they investigate influence of five commercial pectinases) improved release of anthocyanins in the plum juice. Temperature influence probably depends on fruit species. Higher temperature (as blanching) could be resulted with better extraction and higher recovery of anthocyanin pigments in highbush blueberry (Rossia et al., 2003) but in strawberry was opposite (Levaj et al., 2010). Pap et al. (2010) reported that the enzymatic treatment resulted in the increase of anthocyanin and flavonol content of the black currant juice what is noticed in our present work, too.

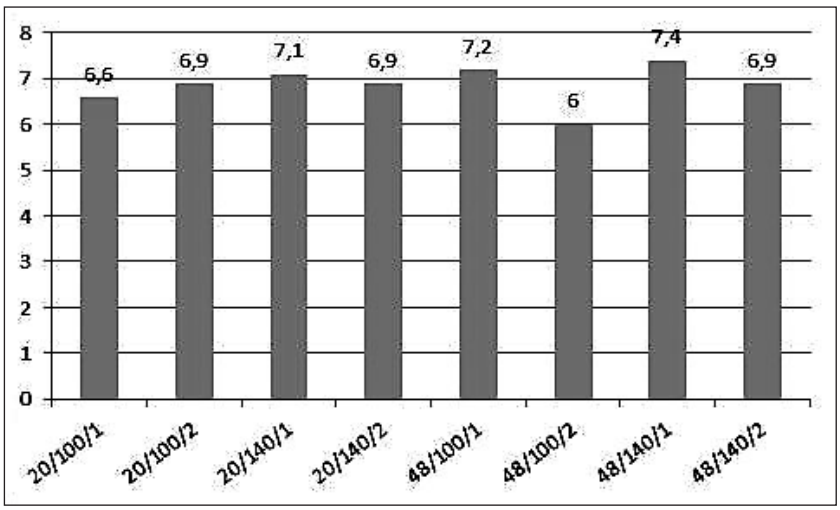

Figure 3. *Overall sensory impression of potability*

Antioxidant capacity (Table 3) was the lowest in the juice 20/100/1, and increasing trend with enzyme concentration and temperature of treatment was observed with exception

Table 4. *Analysis of variance for listed parameters with source of variation (a) temperature, (b) time, (c) enzyme concentration*

a)

Source of variation	Parameter	Mean 20 ºC	Mean 48 ºC	t-value	df	p
Temperature	Dry matter	*15.30000*	*16.47500*	*-12.4144*	6	*0.000017*
	pH	3.720000	3.707500	0.301147	6	0.773466
	Total acidity	*0.765000*	*0.682500*	*3.898121*	6	*0.008001*
	Anthocyanins	79.62500	87.77500	-0,462173	6	0.660242
	Total phenolics	565.1750	1695.475	-1,70462	6	0.139150
	Antioxidant capacity	3.198250	4.023750	-1.34132	6	0.228357
	Overall sensory impression	6.875000	6.875000	0.00	6	1.00000
	Yield	*65.50000*	*80.75000*	*-4.67391*	*6*	*0.003418*

b)

Source of variation	Parameter	Mean 1h	Mean 2h	t-value	df	p
Duration	Dry matter	15.80000	15.97500	-0.361800	6	0.729902
	pH	3.692500	3.735000	-1.11691	6	0.306754
	Total acidity	0.730000	0.717500	0.316862	6	0.762083
	Anthocyanins	65.47500	101.9250	-3.63415	6	0.010911
	Total phenolics	1150.625	1110.025	0.050268	6	0.961540
	Antioxidant capacity	3.293000	3.929000	-0.975665	6	0.366911
	Overall sensory impression	7.075000	6.675000	1.417911	6	0.206000
	Yield	70,25000	76,00000	-0,867873	6	0,418817

c)

Source of variation	Parameter	Mean 100 ppm	Mean 140 ppm	t-value	df	p
Enzyme concentration	Dry matter	15.87500	15.90000	-0.051142	6	0.960872
	pH	3.695000	3.732500	-0.963573	6	0.372471
	Total acidity	0.732500	0.715000	0.447214	6	0.670412
	Anthocyanins	74.70000	92.70000	-1.09946	6	0.313714
	Total phenolics	458.3250	1802.325	-2.26676	6	0.063952
	Antioxidant capacity	3.403250	3.818750	-0.610259	6	0.564074
	Overall sensory impression	6.675000	7.075000	-1.41791	6	0.206000
	Yield	72,75000	73,50000	-0,106803	6	0,918427

of sample 20/100/2 (4.466 mmol TE/L). It seems that influence of duration was in dependence on temperature. Duration at 20 ºC have positive influence on AC but at 48 ºC had an opposite effect. According to ANOVA ($p \leq 0.05$) it was observed that applied pre-treatments had no significant influence on AC (Table 4).

Correlation between AC and anthocyanins or total phenolics is very low. Better correlation was observed only in samples treated at 48 ºC between total phenolics and AC ($r=0.8405$).

Overall sensory impression (Fig. 3) of all juices was high evaluated without significant influences of temperature, enzyme concentration and duration. Nevertheless, the highest score was assigned to sample 48/140/1.

Conclusion

Enzyme concentration of 140 ppm and treatment at 48ºC/2h could be recommended to produce high quality cloudy plum juice especially due to high anthocyanin contents but also due to high yield, total phenolics, and antioxidant capacity. Good sensory acceptance suggests commercial potential of plum juices.

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