

## PHYSICAL AND CHEMICAL PARAMETERS OF STRAWBERRY PUREE

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### Abstract

Practice of the world shows, that more and more often a consumer chooses products, which can be used in nutrition without spending much time for their preparation. Use of fruit desserts in nutrition is one of the ways how to consume vitamins and minerals. The aim was to investigate physical and chemical parameters of strawberry puree from different cultivars and the effect of freezing on its quality. The strawberry cultivars - 'Polka', 'Honeoye', and 'Senga Sengana' harvested in Latvia were used in the study. The strawberries were processed in a blender until obtaining a homogenous mass. The strawberry mass was analyzed fresh and after storage at  $-18\text{ }^{\circ}\text{C}$ . Content of soluble solids was determined according to ISO 2173:2003 using digital refractometer; content of total phenols by spectrophotometer method. Content of total acids was explicit as citric acid. Content of sugars (sucrose, glucose, and fructose) was evaluated by high performance liquid chromatography (HPLC). Content of anthocyanins was evaluated by spectrophotometer method. pH was measured according to LVS 1132:2001, content of vitamin C - AOAC Official Method 967.21. Colour was measured in CIE L\* a\* b\* system. Content of vitamin C in strawberry puree essentially differs ( $p < 0.01$ ) among the researched cultivars and among the types of thermal treatment. Content of vitamin C in strawberry puree has a close correlation with content of total sugars. Close correlation of a\* ( $r=0.810$ ) and b\* ( $r=0.851$ ) with content of total sugars was established. This could be explained with the changes of the content of anthocyanins in strawberry puree. Content of total acids in fresh strawberry puree from the researched cultivars was from  $0.85 \pm 0.03$  to  $0.87 \pm 0.03$  mg  $100\text{ g}^{-1}$ , which increases in average for 4.4% as a result of freezing. The highest content of anthocyanins was in fresh strawberry puree from the cultivar 'Polka', whereas the lowest – from the cultivar 'Honeoye'.

**Keywords:** strawberry puree, freezing, anthocyanins, sugars, vitamin C, colour.

### Introduction

Practice of the world shows, that more and more often a consumer chooses products, which can be used in nutrition without spending much time for their preparation. Use of fruit desserts in nutrition is one of the ways how to consume vitamins and minerals.

Strawberries contain 80–90% water, 0.9–1.2% fibre, 4.5–10% sugar, 0.17–0.25% tannins, vitamins B<sub>1</sub>, B<sub>6</sub>, K, carotene, folic acid, iron, potassium, calcium (Blanda et al., 2009). Strawberries are known as a good source of vitamin C, folates (folic acid) and recently also as a product with high content of various phenols (Proteggente et al., 2002), majority of which exhibits antioxidative capacity (Tulipani et al., 2011). Strawberry quality is also described by content of minerals, carbohydrates, organic acids – malic acid, tartaric acid, citric acid. Citric acid forms around 90% of organic acids present in strawberries (Sturm et al., 2003). It is reduced along ripening and depends on the cultivar (Brasileiro et al., 2011).

According to Sturm et al. (2003) and Pelayo et al. (2003) the most important strawberry quality indicators are content of sugars and total acids, which can be described as a sugar / acid ratio (Pineli et al., 2011). Sugar / acid ratio characterizes degree of sweetness, which depends on cultivar, ripeness, and weather conditions. Sturm et al. (2003) in their research established different results, where total content of acids in some cultivars increased during fruit ripening (content of citric acid in strawberries of cultivar 'Miss' increased from  $0.40\text{ g }100\text{ g}^{-1}$  till  $1.00\text{ g }100\text{ g}^{-1}$ ). This study indicated presence of tartaric acid in amount of

$0.10 \pm 0.04\text{ g }100\text{ g}^{-1}$ . The content of sucrose and glucose was the smallest among all sugars detected in studied strawberries, whereas fructose content was the highest (Sturm et al., 2003). According to the study of Pelayo et al. (2003) dry matter in strawberries was 7.8–16.6%; total sugars (fructose, glucose, sucrose) were 4.4–10.8%, organic acids – 0.49–1.61%. Pineli et al. (2011) observed that values of total anthocyanins increased approximately 9–13-fold from green to pink stage. Cyanidin-3-glucoside contributes to a red colour, whereas pelargonidin is a red-orange pigment. Strawberries are one of the most widely consumed fruits both in fresh and processed form – such as juice, beverage, jam, puree or powder. Storage of fresh strawberries is complicated because they are perishable soft fruits exhibiting an extremely short postharvest shelf-life due to high content of water. Freezing is the best and most effective method of fruit preservation, which maintains taste, appearance, flavour and nutritional value of fresh fruits (Sturm et al., 2003; Ancos et al., 2000; Skrede, 1996). More and more often fruit is frozen for further processing and it is important to study effect of freezing on quality of final products (Skrupskis et al., 2011; Kampuse et al., 2005). Only few researches are available on freezing of fruit puree (Huang et al., 2013). Researchers concluded that fruit with high content of soluble solids are less suitable for freezing (Modise, 2008; Kampuse et al., 2003). Sour fruit juice (Boca et al., 2011), sugar, sugar syrup or honey can be used for puree colour stabilisation during its storage and thawing. Quality of fruit puree is influenced by many factors – differences in cultivars, changes of physical and chemical and

textural parameters during thermal treatment and storage, sensory parameters, as well as microbiological quality.

The aim of the current research was to investigate physical and chemical parameters of strawberry puree from different cultivars and the effect of freezing on its quality.

## Materials and Methods

### Materials

Strawberries of the cultivars 'Polka', 'Honeoye', and 'Senga Sengana' at full ripeness stage, harvested at the end of June or at the beginning of July depending on the type of cultivar, were used for the study. After harvesting, the strawberries were sorted, cleaned, washed, processed in a HR 2000/70 blender (Philips, China) until obtaining a homogenous mass, and placed into 200 mL plastic vessels. The prepared mass was analysed – fresh (just after preparation) and frozen (frozen at  $-25\pm 2$  °C for 20 h, stored in a frozen condition at  $-18\pm 2$  °C for three months, thawed for 16 h till the product temperature reached  $+4\pm 2$  °C; further in the text – frozen puree).

### Methods

For measurement of *soluble solids content*, an ATAGO N20 digital refractometer (Atago Co., Ltd, Japan) was used according to ISO 2173:2003.

*pH* was determined using a Jenway pH meter 3510 (Jenway, UK) according to the standard LVS EN 1132 "pH Determination of Fruit and Vegetable Juice".

*Content of vitamin C* was determined by 2,6-dichloroindophenol titrimetric method (AOAC Official Method 967.21).

*Content of sugars (sucrose, glucose, and fructose)* was determined using a LC-10AD Prominence (Shimadzu Japan) high performance liquid chromatograph (HPLC) equipped with refractive index detector RID-10A and autosampler SIL-10AF. Test conditions: mobile phase mixture of acetonitrile with deionized water in ratio 80 : 20 (v/v); flow rate – 0.6 mL min<sup>-1</sup>; temperature of column and detector – +50 °C; volume of the injected sample – 10 µL.

Strawberry puree samples for sugar testing were prepared adding 40 mL of deionized water (+80 °C) to 10 grams of puree and mixing it for 1 min. Then sample was centrifuged (10 000 g / 5 min at +20 °C). The procedure was repeated twice, then supernatant was cleared, and finally filtered through membrane filter (0.45 µm). Each sample was analysed in triplicate. Chromatograph software calculated content of glucose, fructose, and sucrose comparing chromatograms of puree with standard curves of respective sugar.

*Content of total acids* was determined by potentiometric titration method and was converted to citric acid.

The *total phenolic content* (TPC) of strawberry puree was determined according to the Folin-Ciocalteu spectrophotometric method (Singleton et al., 1999)

with some modifications. For analysis 4–6 grams of puree was taken. The absorbance was measured at 765 nm using a UV-1650 PC spectrophotometer (Shimadzu, Japan) twice for each of the duplicate samples. Total phenols were expressed as gallic acid equivalents (GAE) per 100 grams of puree.

The *content of anthocyanins* was determined by the spectrophotometric method (Moor et al., 2005). For determination, 20 grams of strawberry puree was homogenized together with 40 g of ethanol and hydrochloric acid mixture (85 : 15 v/v) for 1 min. After filtration sediments were rinsed three times with 10 mL ethanol and 1.5 M HCl reagent (3 x 10 mL). The absorbance of filtrate was measured at 535 nm using a UV-1650 PC spectrophotometer (Shimadzu, Japan) in triplicate.

*Colour* was measured in CIE L\*a\*b\* colour system by a colorimeter (Tec PCM/PSM, USA). Strawberry puree before colour measurement was placed in a 100 mL PET containers, to have the same thickness of puree layer. Colour was measured in eight randomly selected spots. Data was processed in ColorSoft software.

A colour spectrum was determined in a three coordinate system: L\* represents lightness, where L\*=100 – white, L\*=0 – black. Value of colour component a\* is from -a\* (green) to +a\* (red), component b\* – from -b\* (blue) to +b\* (yellow). Colour changes in puree after freezing compared to fresh puree were described by total colour difference  $\Delta E^*$  (MacDougall et al., 2002). Total colour difference ( $\Delta E^*$ ) was calculated according to the equation:

$$\Delta E^* = \sqrt{(L^* - L_0^*)^2 + ((a^* - a_0^*)^2 + (b^* - b_0^*)^2)}, \quad (1)$$

where  $L_0^*$ ;  $a_0^*$ ;  $b_0^*$  – values for fresh sample;

$L^*$ ;  $a^*$ ;  $b^*$  – values for frozen sample.

In the research calculations were carried using *MS Excel* program and *SPSS 16* statistics software. The hypothesis set was checked with the p-value method. Factors were estimated as significant when the p-value was  $< \alpha_{0.05}$ . For interpretation of the results it is assumed, that  $\alpha=0.05$  with 95% reliability, if not indicated otherwise. The following tests and analyses were used: one-factor and two-factor variance analysis (ANOVA), correlation and regression analysis. If the correlation between variables is linear, the determination coefficient coincides with the correlation coefficient:  $R^2$  is equal to  $r^2$ . If the value of correlation coefficient is  $0.5 \leq |r| \leq 0.8$ , then there is medium close linear correlation between the examined variables. If  $|r| > 0.8$ , then there is a close linear correlation between the examined variables (Arhipova, Bălița, 2006).

## Results and Discussion

### Soluble solids

Soluble solids content in fresh strawberry puree samples ranged from 8.54 °Brix to 10.50 °Brix

(Table 1). After freezing and thawing cycle content of soluble solids decreased possibly due to drip loss.

Table 1

Cultivar	Soluble solids, °Brix	
	fresh	frozen
	‘Senga Sengana’	9.32±0.06
‘Polka’	10.50±0.08	9.98±0.05
‘Honeoye’	8.54±0.19	8.39±0.05

Pineli et al. (2011) observed lower content of soluble solids (5.0–7.9 °Brix).

*pH*

Values found for pH tended to be lower for strawberries of cultivar ‘Honeoye’ (Table 2).

Table 2

Cultivar	pH	
	fresh	frozen
	‘Senga Sengana’	3.43±0.02
‘Polka’	3.44±0.01	3.32±0.01
‘Honeoye’	3.24±0.02	3.18±0.03

pH determined for strawberry purees in the current research are within the same range as observed by Pineli et al. (2011).

*Content of vitamin C*

Content of vitamin C in strawberry puree essentially differed ( $p < 0.01$ ) among the researched cultivars (Table 3).

Table 3

Cultivar	Content, mg 100 g <sup>-1</sup>	
	fresh	frozen
	‘Senga Sengana’	23.51±0.38
‘Polka’	21.13±0.23	15.81±0.32
‘Honeoye’	19.40±0.27	14.50±0.30

The most significant differences were found between puree made from ‘Senga Sengana’ and ‘Polka’, as well as puree of ‘Senga Sengana’ and ‘Honeoye’. Content of vitamin C in fresh puree was between 19.40±0.27 mg 100 g<sup>-1</sup> (‘Honeoye’) and 23.51±0.38 mg 100 g<sup>-1</sup> (‘Senga Sengana’). During fruit homogenization air is incorporated in puree, consequently content of vitamin C is reduced due to presence of oxygen. As a result fruit puree contains smaller amount of vitamin C compared to whole fruits. Literature data show, that vitamin C content in strawberries (not puree) of cultivar ‘Polka’ was 58–63 mg 100 g<sup>-1</sup> (Laugale et al., 2000); Finnish

researchers depending on harvest year detected its content from 48.0±1.6 to 62.0±1.6 mg 100 g<sup>-1</sup> (Hakala et al., 2003). Whereas strawberries of cultivar ‘Honeoye’ contained more vitamin C – 80–87 mg 100 g<sup>-1</sup> (Laugale et al., 2012) and 54.1±3.7–71.3±3.1 mg 100 g<sup>-1</sup> (Hakala et al., 2003). In cultivar ‘Senga Sengana’ it was from 43.6±2.5 to 54.2±2.5 mg 100 g<sup>-1</sup> (Hakala et al., 2003). Another Finnish study (Hägg et al., 1995) in various fresh strawberries determined 56–99 mg 100 g<sup>-1</sup> of vitamin C, which decreased by 34% as a result of freezing. Our research reveals that content of vitamin C is significantly higher ( $p < 0.01$ ) in fresh puree compared to puree after freezing. The decrease of vitamin C content in all studied purees was 18.8% on average. Velde et al. (2013) demonstrated that content of vitamin C in frozen strawberries was 44.5±3.2 mg 100 g<sup>-1</sup>.

Vitamin C content has a close correlation with total sugar content in strawberry puree ( $r = 0.830$ ). Data shows: the higher total sugar content in strawberry puree, the higher vitamin C content (Fig. 1).

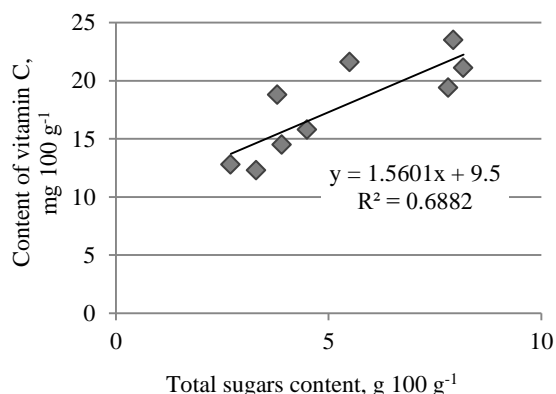


Figure 1. Correlation between content of vitamin C and total sugars in strawberry puree

Regression equation shows – if total sugar content is increased by 1 g 100 g<sup>-1</sup>, content of vitamin C will increase by 1.56 mg 100 g<sup>-1</sup>. It can be explained by the processes taking place during fruit maturation – both synthesis of vitamin C and sugars occurs simultaneously.

*Content of total sugars*

There is no essential difference ( $p = 0.117$ ) in content of total sugars of strawberry puree between cultivars, whereas it is essentially ( $p < 0.001$ ) influenced by the freezing (Fig. 2). Total sugar content in fresh strawberry puree is from 7.82 to 8.17 g 100 g<sup>-1</sup>, which is similar to the result established for strawberry variety ‘Mohawk’ – 7.41 g 100 g<sup>-1</sup> (Sturm et al., 2003); whereas German study (Keutgen et al., 2007) show total sugar content of 6.33±0.39 g 100 g<sup>-1</sup>, which is lower compared to our study. Total sugar content in strawberry puree decreased during freezing in average by 41.9%.

Content of individual sugars – sucrose, glucose and fructose in both fresh and frozen strawberry puree is presented in Figure 3.

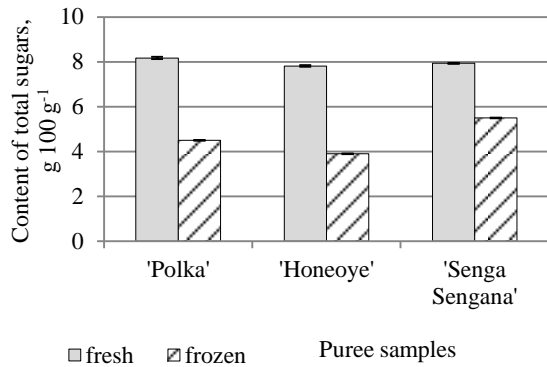


Figure 2. Content of total sugars in strawberry puree

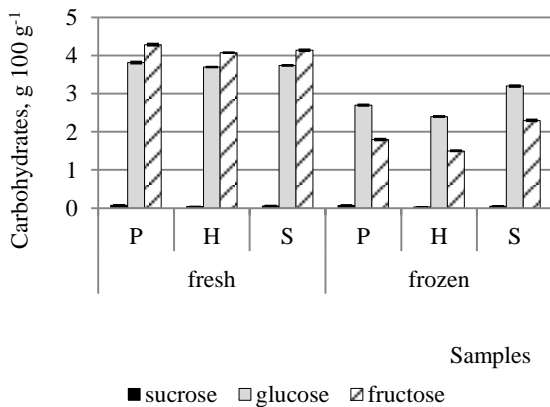


Figure 3. Content of sucrose, fructose and glucose in strawberry puree  
P – 'Polka'; H – 'Honeoye'; S – 'Senga Sengana'

Evaluation of individual sugars (sucrose, glucose, and fructose) in strawberry puree show that the highest content exhibited *fructose* from  $4.08 \pm 0.01$  to  $4.29 \pm 0.01$  g 100 g<sup>-1</sup>. Its content did not differ among studied cultivars ( $p=0.124$ ). Sturm et al. (2003) in their study found that fresh strawberries of various cultivars contained  $0.04$ – $3.30$  g 100 g<sup>-1</sup>, which is lower compared to our results. Essential differences in content of fructose ( $p<0.001$ ) are established between fresh and frozen strawberry puree. Its content decreases as a result of freezing (approx. by 55.2%).

Content of *glucose* in fresh strawberry puree is from  $3.70 \pm 0.01$  to  $3.81 \pm 0.03$  g 100 g<sup>-1</sup>, what is less than content of fructose in it. Content of glucose does not differ among studied cultivar ( $p=0.109$ ) purees. Slovenian research (Sturm et al., 2003) established content of glucose in strawberries of various cultivars in the range from  $1.63$  to  $2.82$  g 100 g<sup>-1</sup>, which is lower compared to our study. Content of glucose in strawberry puree has a tendency to decrease as a result of freezing (in average for 26%), as it was observed with content of fructose. Comparing content of sugars in fresh strawberry purees from all the researched cultivars, content of *sucrose* in them is the lowest. It is from  $0.04 \pm 0.001$  to  $0.07 \pm 0.003$  g 100 g<sup>-1</sup> and it does not differ substantially among cultivars ( $p=0.301$ ),

however it is essentially ( $p<0.001$ ) influenced by the freezing.

#### Content of total acids

Content of total acids in fresh strawberry puree does not essentially ( $p=0.164$ ) differ among cultivars and it is from  $0.85 \pm 0.03$  to  $0.87 \pm 0.03$  mg 100 g<sup>-1</sup>, which increases in average for 4.4% as a result of freezing (Table 4).

Table 4

#### Content of total acids in strawberry puree

Cultivar	Content, mg 100 g <sup>-1</sup>	
	fresh	frozen
'Senga Sengana'	$0.86 \pm 0.03$	$0.89 \pm 0.02$
'Polka'	$0.87 \pm 0.03$	$0.90 \pm 0.03$
'Honeoye'	$0.85 \pm 0.03$	$0.90 \pm 0.02$

Content of total acids has a negative close correlation with content of vitamin C in strawberry puree ( $r=0.820$ ). Data show that content of vitamin C is lower in strawberry puree, which has higher content of total acids. This can be explained by the ripeness stage of strawberries. This is also confirmed by close negative correlation ( $r=0.916$ ), which exists between content of total sugars and acids in strawberry puree (Figure 4).

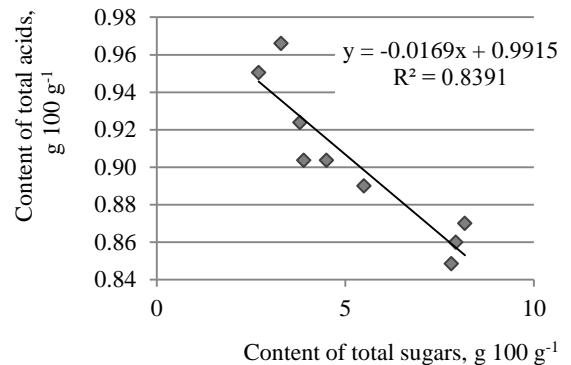


Figure 4. Correlation between content of total acids and sugars in strawberry puree

The correlation shows that the increase of total sugars by 1 g 100 g<sup>-1</sup>, results in decrease of total acids in strawberry puree by  $0.0169$  g 100 g<sup>-1</sup>. This might be due to the physiological properties of fruits when with increased stage of ripeness increase in sugar content and decrease in total acids is observed (Brasileiro et al., 2011). *Sugar/acid ratio* was not significantly different among cultivars ( $p=0.138$ ) and it ranged from 9.2 to 9.4. Fresh strawberry purees from researched cultivars may be characterized as "sour", which sugar/acid ratio does not change essentially during freezing – they also can be characterised as "sour". Sturm et al. (2003) found sugar/acid ratio at full maturity stage around 6.5 in average, with higher values for some cultivars – 8.7 (cultivar 'Mohawka'), whereas Keutgen et al. (2007) reported sugar/acid ratio around 10.13, which is similar to our result.

Content of total phenolic compounds

Content of total phenolic compounds in strawberry puree (Table 5) does not significantly differ among cultivars (p=0.471).

Table 5

Cultivar	Content, mg 100 g <sup>-1</sup>	
	fresh	frozen
'Senga Sengana'	141±14	1591±28
'Polka'	181±16	1733±27
'Honeoye'	130±11	2180±29

Pineli et al. (2011) reported higher content of phenols in fresh strawberries compared to our results 223.46±6.96 mg 100 g<sup>-1</sup>. Our research revealed that content of total phenols in fresh strawberry puree essentially differs (p=0.001) from their content in frozen puree – in average by 91%. The same conclusion was drawn in research of Blanda et al. (2009), who established higher total phenol content in frozen fruits compared to fresh ones. Higher content possibly was formed in hydrolysis of polymers or in metabolism processes, which is created by osmotic stress in fruits (Blanda et al., 2009).

Content of anthocyanins

Content of anthocyanins in strawberry puree was essentially (p<0.01) different among the researched cultivars (Figure 5). The highest content of anthocyanins was in fresh strawberry puree from the cultivar 'Polka' (30.04±0.63 mg 100 g<sup>-1</sup>), whereas the lowest – from the cultivar 'Honeoye' (14.91±0.41 mg 100 g<sup>-1</sup>).

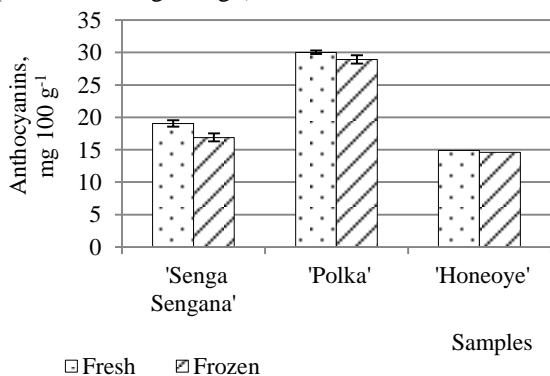


Figure 5. Content of anthocyanins in strawberry puree

During freezing their content decreased for 2.05% to 11.32%. During freezing content of anthocyanins was preserved better than under the influence of pasteurisation, alongside better preserving the red colour characteristic to strawberries (Boca et al., 2011). Content of anthocyanins has a close correlation with the content of soluble solids in strawberry purees (r=0.833). In strawberry purees, with higher content of soluble solids, the content of anthocyanins was higher.

Literature show anthocyanins content in strawberries 10–80 mg 100 g<sup>-1</sup>. Pineli et al. (2011) indicated that anthocyanins content in unripe berries was 2.35±0.35 mg 100 g<sup>-1</sup>, and it increased till 22.64±0.66 mg 100 g<sup>-1</sup> upon ripening. Aaby et al. (2012) study demonstrated higher anthocyanins content, in fresh strawberries of cultivar 'Polka' it was 37.2 mg 100 g<sup>-1</sup>, in 'Senga Sengana' – 27.4 mg 100 g<sup>-1</sup>. Whereas Velde et al. (2013) in frozen strawberries established similar anthocyanins content to our study 22.1±4.2 mg 100 g<sup>-1</sup>.

Strawberry puree colour

Colour component a\*, b\* and L\* values of fresh and frozen strawberry puree does not differ essentially in cultivars (p>0.05), whereas there are essential (p<0.001) differences of them in the types of treatment. This is also shown by total colour changes (Fig. 6).

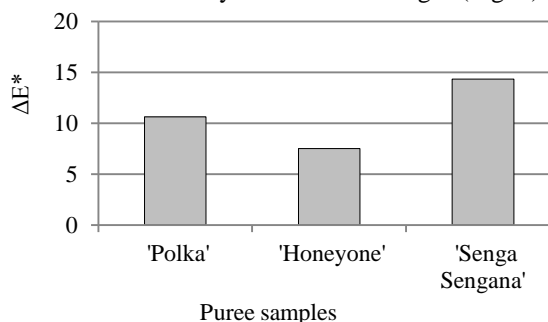


Figure 6. The influence of freezing on the total colour difference (ΔE\*) of strawberry puree

Colour component a\* and b\* value of strawberry puree has a close correlation with content of total sugars in strawberry puree. Data, displaying the close correlation a\* (r=0.810) and b\* (r=0.851) for the value with content of total sugars in strawberry puree, show that in samples, where content of total sugars is higher, red colour (a\*) and yellow (b\*) colour intensity increases. This could be explained with the changes of the content of anthocyanins in strawberry puree, because they form red colour characteristic to strawberries and they are glucosidically bound with sugar.

Conclusions

Content of vitamin C in strawberry puree essentially differs (p<0.01) among the researched cultivars and between fresh and frozen-thawed puree. Close correlation of colour components a\* (r=0.810) and b\* (r=0.851) with content of total sugars was established. Content of total acids in fresh strawberry puree from the researched cultivars was from 0.85±0.03 to 0.87±0.03 mg 100 g<sup>-1</sup>, which increases in average by 4.4% as a result of freezing. The highest content of anthocyanins was in fresh strawberry puree from the cultivar 'Polka', whereas the lowest – from the cultivar 'Honeoye'.

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