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The effect of heat treatment on the antioxidant activity of sour cherry jams

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SUMMARY

Sour cherry (Prunus cerasus) is a valuable fruit known for its high antioxidant content. Its bioactive substances contribute to health maintenance, as they have strong anti-inflammatory and free radical scavenging properties. Jams made from sour cherries provide a concentrated form of the antioxidant content of fruit, thus can play an important role in a balanced diet. Heat treatment is an essential part of the jam-making process, as it ensures the microbiological stability and longer shelf life of the product. At the same time, heat can significantly affect the antioxidant content of the fruit. In this study, the authors compared the antioxidant content of six different sour cherry jams. Based on the obtained results, it was concluded that the fruit content of sour cherry jams alone is not sufficient to estimate their antioxidant capacity, but the extent of the effect of heat treatment on it is generally independent of the nature of the products. This result highlights that the fruit content and the applied technology play an important role in preserving the antioxidant content of fruits during product processing.

Keywords: *sour cherry; jam; heat-treatment; antioxidant*

INTRODUCTION

Regular consumption of fruits and vegetables is key to a healthy lifestyle, as they are rich in fiber, vitamins, minerals, and also rich sources of antioxidants and other bioactive substances that support our health. Consumption of these foods have a proven disease-preventing effect. Their daily consumption contributes to reducing the development of cardiovascular diseases and various types of cancer. (Riboli et al., 2003; Slavin et al., 2012)

Sour cherry (*Prunus cerasus*) is a stone fruit, rich in bioactive compounds and has a wide range of products for consumers due to its extremely versatile use (Kirakosyan et al., 2009; Ferretti et al., 2010). Sour cherries have recently been referred to as a "superfood" due to their excellent beneficial effects. They contain various polyphenolic compounds that are known for their proven disease-preventive effects. The anthocyanins in sour cherries, which belong to the flavonoid group within polyphenols, have strong antioxidant activity, thus contributing greatly to the defense against free radicals generated in the body. Among the vitamins in sour cherries, the importance of vitamin C is outstanding, as it plays an important role in collagen formation, strengthens the immune system and helps in the absorption of iron (Chaovanalikit et al., 2004; Ananya et al., 2022). Sour cherry is less often consumed fresh than other fruits, like sweet cherry, because the acid-sugar ratio in them makes their taste slightly tart. Sour cherry products are available almost everywhere, and as it is a seasonal fruit, in order to be able to consume them all year, various preservation methods are available to conservate its bioactive compounds. Beside consuming them as fresh fruit, several other forms are available in the market, such as preserves, frozen products, syrups and jams (Blando et al., 2019; Branka et al., 2010; Hassan et al., 2015).

Different flavored fruit jams are not only delicious, but they may also contain vide range of valuable bioactive compounds that contribute to improving the human physiological functions. The amount of their anthocyanin and antioxidant content of fruit jams is decisive, since these bioactive compounds play a huge role in defense of human body (Bursać et al., 2015). Antioxidants do not only play a role in protecting against free radicals, but also contribute to reducing inflammatory processes, thus supporting the immune system (Ilkay et al., 2009; Anuj et al., 2016). In the case of a jam, the amount of antioxidants and vitamins degrades to a certain extent during processing, since the raw materials undergo heat treatment during production, therefore jams basically have less bioactive substances than the fresh fruit. Heat treatment degrades or inactivates vitamins, flavonoids, and other compounds, rendering them less beneficial. For example, vitamin C is very sensitive to heat, so degradation can be high during jam production. In order to be able to consume sour cherry products all year round, they need to be processed in some way, the main thing is to strive for the applied production technology to preserve the valuable compounds in the products as much as possible (Kim et al., 2006; Shinwari et al., 2018; Martinsen et al., 2020; Márta et al., 2012). On the other hand. it is advantageous to have as high fruit content of jams as possible and also as low added sugar content as it is possible to keep these beneficial properties and to avoid the negative effects of high sugar intake. However, without added sugar it is very hard to produce delicious sour cherry product because of the tart taste of fruit. Penta Familia Cooperative produces a premium sour cherry jam product from Cigánymeggy, which cultivar is a traditional one in Szabolcs-Szatmár-Bereg county and trying to keep its beneficial chemical composition in the products. During further development of the product, the question arose regarding the extent of degrading effect

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of heat treatment on the special food matrix of sour cherry jam, and whether there is a difference in the behavior of jams available on the market under the influence of additional heat treatment. To investigate this, different sour cherry jams were subjected to heat treatment as an ingredient in homemade pastries, then changes in the amount of bioactive substances and antioxidant activity was investigated.

MATERIALS AND METHODS

Sample collection and preparation

During sample collection, special attention was paid to collect premium quality products from commercially available sour cherry jams, but there was no requirement on their fruit content. The content of fruit and other raw materials aimed to cover the product range of current Hungarian market. This made possible to evaluate the correlations between the fruit content and the decrease in antioxidant content during heat treatment.

The collection of market samples was done in the autumn of 2024. Jam 1 was the premium sour cherry jam product produced by Penta Família Cooperative, provided by the company. The other five sour cherry jam products were purchased from commercial sources. *Table 1* presents general information about the compared samples.

Table 1. **General information about the composition of sour cherry jam samples**

Sample id	available information about the product
Jam 1	53.5 g sugar content; 90% fruit content
Jam 2	50.8 g sugar content; 100% fruit content; made with the addition of grape juice concentrate, pectin and lemon juice
Jam 3	58 g sugar content; 80-90% (not indicated) fruit content; made with the addition of pectin
Jam 4	9 g sugar and 27 g xylitol; 80% fruit content; made with the addition of apple, lemon concentrate and pectin
Jam 5	48 g sugar content; 60% fruit content; made with the addition of lemon juice concentrate and pectin
Jam 6	39 g sugar content; 60% fruit content; made with the addition of lemon juice concentrate and pectin made with the addition of lemon juice concentrate and pectin

Jam samples were stored in a dark, cool place before tests. A total of two samples were collected from every jam product: one sample was tested after opening the jars and the second after dough preparation, filling and heat treatment (baking). At the beginning of the experiment, the samples were placed in sterilized jars, and the test was started immediately after opening those. The jams were filled into homemade sweet dough, and the rolls were baked in an electric oven at 190 °C for 30 minutes (*Figure 1*). After the baking process, the jams were taken out of the pastry and the analysis was started immediately after cooling down.

Figure 1. **Pastry rolls before and after baking**

Analytical methods

Analytical measurements were carried out in the laboratories of the Faculty of Agricultural and Food Sciences and Environmental Management of the University of Debrecen. Dry matter content, total polyphenol content and total flavonoid content were measured and antioxidant activities by FRAP and DPPH assays were evaluated.

The total polyphenol content was determined according to the Folin-Ciocalteu method (Singleton et al., 1999). 5 g of the jam samples were measured and diluted to 50 ml with 80%:20% methanol-distilled water mixture, then this solution was filtered through filter paper. From this solution, 0.5 ml was taken, to which 2.5 ml of 0.2 N Folin-Ciocalteu reagent was added. After 5 min, 2 ml of 75 g l^{-1} sodium carbonate solution (Na_2CO_3) was added. Thismixture was incubated for 2 h and absorbance measured at 760 nm in a spectrophotometer. The blank solution was methanol. The results were expressed as gallic acid equivalent (GAE) mg/100 g (Aline et al., 2005).

The total flavonoid content was determined using the color reaction method developed by Zhishen, Mengcheng and Jianming (1999) and Zhishen et al. (1999). 5 g of the jam samples were weighed and diluted to 50 ml with 80%:20% methanol-distilled water mixture, then this solution was filtered through filter paper. 4 ml of distilled water was added to a 10

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ml test tube, then 1 ml of the filtered samples and standard solutions were weighed into the test tubes. Then, 0.3 ml of 5% $NaNO_2$ solution was added. After 5 minutes, 0.3 ml of 10% $AlCl_3$ solution was added, and 2 ml of 1 M NaOH solution was added after another 6 minutes. After that, 2.4 ml of distilled water was pipetted into each test tube and they were shaken thoroughly. The absorbance of the resulting pink solution was measured at 510 nm using spectrophotometer. The results were expressed as catechin equivalent (CE) mg/100 g (Kim et al., 2003).

The FRAP method is widely used to measure the total antioxidant capacity of different foods and plant extracts. The method is based on the reaction between 2,4,6-tris-(2-pyridyl)-s-triazine (TPTZ) and iron(III) chloride hexahydrate ($FeCl_3 \cdot 6H_2O$), during which the TPTZ complex becomes almost colorless, and then forms a blue iron complex at the end of the reaction. 25 mg of the sample was measured, then 1 ml of distilled water was added to it. After mixing it for 1 minute, the mixture was centrifuged, and then the supernatant was used for the measurement. The measurement requires FRAP reagent (acetate buffer, $FeCl_3$ solution, TPTZ solution), which must be stored in the dark and its pH has to be adjusted to 3.6. Acetate buffer was prepared as follows: 3.1 g sodium acetate·$3H_2O$ was dissolved in 16 ml acetic acid, then filled to the mark in the liter volumetric flask. $FeCl_3$ solution contained 54 mg $FeCl_3$ dissolved in 10 ml distilled water. TPTZ solution was prepared as 31.23 mg 2,4,6-tris-(2-pyridyl)-s-triazine (TPTZ) was dissolved in 10 ml distilled water, then 33.5 µl c.c. HCl was added. When assembling the reaction mixture, 10 µl of the solutions were measured, 65 µl of distilled water was added, and finally 2250 µl of FRAP reagent was measured. After 8 minutes of incubation time, the absorbance of the samples were measured at 593 nm using a spectrophotometer. The measured value can be calculated using the calibration curve, which can be prepared by measuring a dilution series of ascorbic acid of known concentration. (Benzie and Strain, 1996).

During the DPPH test, 25 mg of the jam was measured and mixed with 1 ml of methanol for 1.5 minutes, after which it was centrifuged and the supernatant was used. The DPPH (2,2-diphenyl-1-picrylhydrazyl) reagent was prepared by dissolution of 9 mg of DPPH in 100 ml of methanol. For the preparation of calibration curve, 1 mg/ml Trolox solution (10 mg of Trolox dissolved in 10 ml of methanol) was used. During the preparation of the reaction mixture, 100 µl of the sample was added to 1400 µl of methanol in a test tube and then 1500 µl of DPPH solution was pipetted. After 30 minutes, the absorbance was measured using a spectrophotometer at 517 nm (Pasqualone et al., 2014).

All the measurements were performed in duplicate. Values are based on fresh weight.

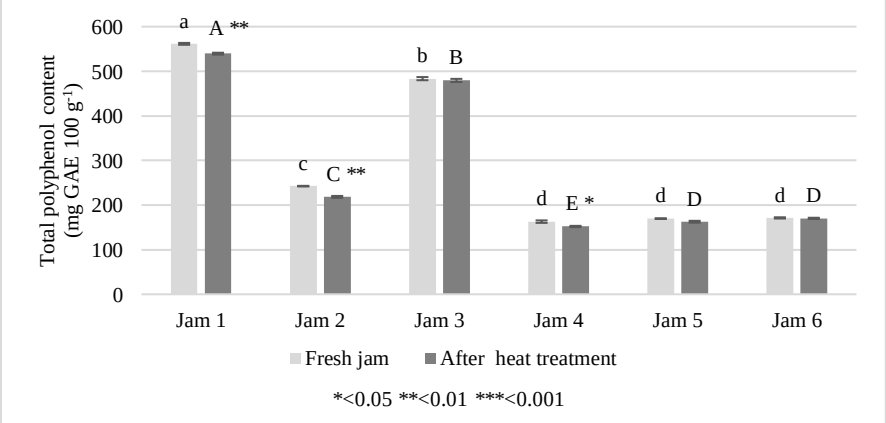
Statistical analysis

The antioxidant concentrations and activities of different jams were compared using one-way ANOVA and significant differences between means were evaluated by Tukey's post hoc test. For the evaluation of the effect of heat treatment on the different products, t-test was used.

RESULTS AND DISCUSSION

Evaluating the results of the raw cherry jams, it was found that the total polyphenol content of "Jam 1" is the highest with 561.5 ± 2.12 mg GAE 100 g^{-1} (FW). The total polyphenol content of "Jam 3" showed a slightly lower value with 483.5 ± 3.52 mg GAE 100 g^{-1}. The other jams, however, showed much lower values. Based on the changes observed in the total polyphenol content after heat treatment, it can be stated that in the case of "Jam 1" ($p<0.01$), "Jam 2" ($p<0.01$) and "Jam 4" ($p<0.05$) there were significant differences between the raw and heat-treated values. In the case of the other jams, the polyphenol content did not decrease significantly as a result of heat treatment (*Figure 2*).

Figure 2. **Comparison of total polyphenol content of raw and heat-treated sour cherry jams**



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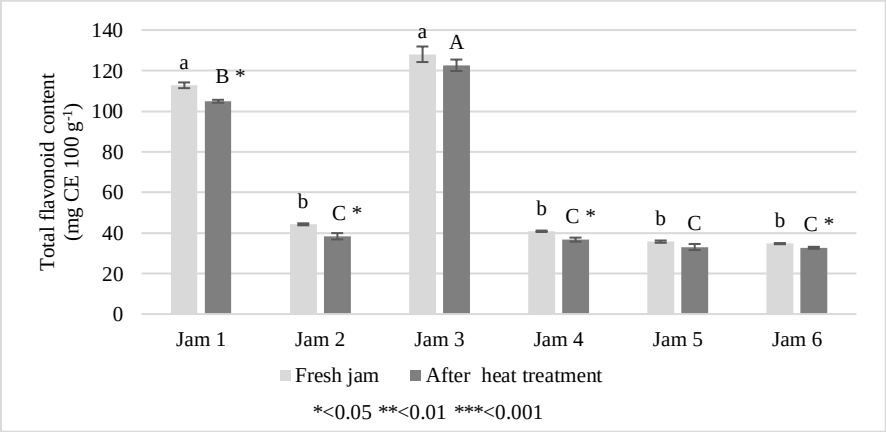
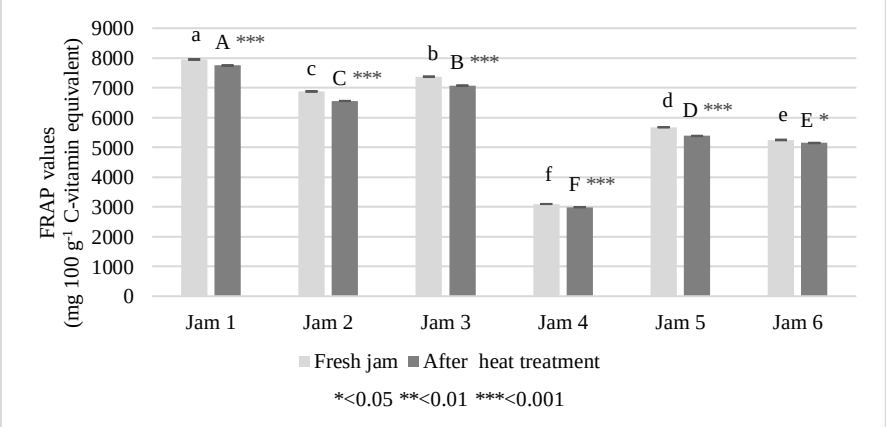
In the case of total flavonoid content the highest values were measured in "Jam 1" (113 ± 1.41 mg CE 100 g^{-1}) and "Jam 3" (143 ± 3.83 mg CE 100 g^{-1}). Statistically, these two jams did not differ significantly from each other. The other commercial jams had almost a third of the flavonoid content and there was no statistically significant difference amongst them. As a result of heat treatment, a significant decrease in the total flavonoid content was observed in "Jam 1" ($p<0.05$), "Jam 2" ($p<0.05$), "Jam 4" ($p<0.05$) and "Jam 6". No significant decrease was detected in the other jams (*Figure 3*).

Figure 3. **Comparison of total flavonoid content of raw and heat-treated sour cherry jams**



Regarding FRAP values, it can be seen in *Figure 4* that the highest value was detected in the variety "Jam 1" (7950 ± 4.40 mg 100 g^{-1} C-vitamin equivalent) after opening. Statistically, all 6 types of jams' FRAP values are significantly different from each other. The jam with the closest FRAP value to "Jam 1" is "Jam 3". As a result of heat treatment, a significant decrease was observed in the FRAP values in all six tested jams, but the jam with the highest value after heat treatment was "Jam 1" again, with a value of 7747 ± 5.63 mg 100 g^{-1} C-vitamin equivalent).

Figure 4. **Comparison of FRAP values of raw and heat-treated sour cherry jams**



Based on the results of the DPPH assay, it can be claimed that the results of "Jam 4" (89.30 ± 0.04 SC% (FW)), "Jam 5" (89.2 ± 0.28 SC% (FW)) and "Jam 6" (88.85 ± 0.77 SC%) showed the highest values in fresh condition and these three jams did not show statistically verified difference from each other in their antioxidant activity. The lowest DPPH value was shown by "Jam 1" (59.55 ± 0.07 SC% (FW)). During the examination of the effect of heat treatment, a significant decrease was detected in the jam products measured by the DPPH method for "Jam 1" ($p<0.05$) and "Jam 2" ($p<0.05$) (*Figure 5*).

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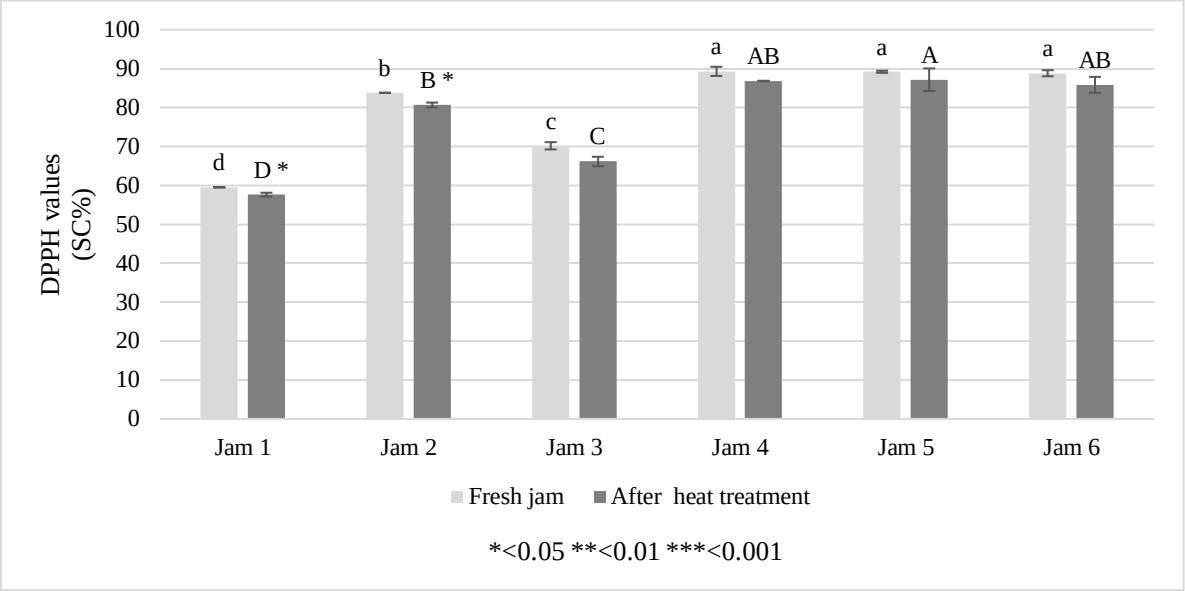
Figure 5. **Comparison of DPPH values of raw and heat-treated sour cherry jams**



CONCLUSIONS

Based on the tests, the Meggyerő premium sour cherry jam showed the highest values for polyphenol and FRAP antioxidant activity. For the flavonoid assay, the fresh sample, was not significantly different from the jam 3 sample, but was the second highest after heat treatment. In the DPPH test is showed a lower value compared to the other samples. Although a significant decrease was observed in this jam in all cases as a result of heat treatment, the values remained outstandingly high. In conclusion it can be stated that the high fruit content and the applied preparation technology contribute significantly to the outstanding quality of the analyzed jam products.

Furthermore, we observed higher FRAP values in Jam1, Jam2, and Jam3 products, but lower DPPH values. The diversity of antioxidants found in foods have different chemical properties and shelf-life profiles, which affect their detectability and mechanisms of action. The DPPH assay primarily measures the free radical scavenging capacity of fat-soluble antioxidants, while the FRAP method examines the reducing capacity of water-soluble antioxidants. These 3 jams contain over 50 g 100 g^{-1} of sugar and their fruit content is also higher than the other jams. Further studies are necessary to determine the effect of fruit and sugar content on the change in FRAP and DPPH values clearly and the kind of ingredients or compound is responsible for the higher DPPH values.

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