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# Chemical and sensory properties of fruit jams affected by bamboo fiber fortification

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## ABSTRACT
The study aimed at producing fiber fortified fruit jams and to evaluate the fortification influence on nutritional, textural and sensory characteristics. Following fruits were used for the fruit jams preparation: apricots (*Prunus magnapavliciana*), redcurrants (*Ribes rubrum* Detvan), cherries (*Prunus avium* Chestnut) and sour cherries (*Prunus cerasus* L). Produced jams were fortified with different percentages of bamboo fiber (1 %, 5 % and 10 %). Dry matter content, polyphenol content, textural and sensory properties were measured in experimentally produced fruit jams. Principal component analysis showed the influence of bamboo fiber fortification on measured parameters. Sensory properties were mainly influenced by 5 % and 10 % fiber addition. The addition of 1 % of bamboo fiber did not affect significantly sensory properties of experimentally produced fruit jams. The obtained results clearly indicated that a higher percentage of fiber fortification leads to reduce sensory characteristics. These changes, as the study showed, can certainly cause the product not acceptance from the side of consumers.

**Keywords:** *polyphenol content; textural parameters; sensory properties; principal component analysis.*

## 1. INTRODUCTION

Fruit consumption is increasing worldwide due to their beneficial nutritional rich compounds. Fruits are also a good source of antioxidants. Disadvantage of fruits can be considered their short shelf life. The processed products, such as fruit jams, often represent the way to prolong fruit availability for consumers [1,2]. Consequently, fruits are mainly processed into products, such as fruit jams, and smaller percentages are consumed fresh [3]. Fruit jams represent an important commodity for consumers in the market, worldwide [4,5]. The whole principle of jam production is very simple since it is mainly based on its composition; mainly containing only fruit, sugar and certain gelling agent [6].

The European Food Safety Authority (EFSA) considered dietary fibre to be non-digestible carbohydrate, including lignin, cellulose, hemicelluloses, pectin, hydrocolloids (gums, mucilage, glucans), fructooligosaccharides, galacto-oligosaccharides, galacto-oligosaccharides resistant starch - consisting of physically sealed starch, some types of crude starch granules, retrograded amylose, chemically or physically modified starches, and lignin associated with fibre polysaccharides [7].

The chemical composition of bamboo fibre consists mainly of cellulose, hemicellulose and lignin. These ingredients contain mainly glucans (making up to 90% of the total bamboo fibre composition). The other ingredients are proteins, fats, pectin, tannins, pigments and ash. These components play an important role in the physiological activity of bamboo and are found in the cell cavity [8]. Fibres intake brings many health benefits. Sufficient fibre intake reduces the risk of developing many diseases: heart disease, stroke, hypertension, diabetes, obesity and some gastrointestinal disorders. In addition, increased dietary fibre consumption improves blood lipid levels and lowers blood pressure [9]. Food fortification is one of the main strategies identified by the World Health Organization. Staple food (cereals, roots and tubers) same as condiments (salt and oil) is targeted as good food commodities for the fortification, since they are broadly consumed [10].

The aim of the study was to fortify fruit jams with bamboo fibre and evaluate their nutritional, textural and sensory characteristics, influenced by the fortification.

## 2. MATERIALS AND METHODS

The material used for experimentally produced jams was the following fruits: apricots (*Prunus magnapavliciana*), redcurrants (*Ribes rubrum Detvan*), cherries (*Prunus avium Chestnut*) and sour cherries (Prunus cerasus L.). The samples were made at the University of Veterinary and Pharmaceutical Sciences Brno, the Department of Hygiene and Technology of Plant Origin Foodstuffs (Faculty of Veterinary Hygiene and Ecology). After washing and pitting of fruits, jams were prepared according to Table 1. Juicing was done only with redcurrants. After 3 minutes of boiling, sugar (sugar crystal, retail seller: Tesco) was added with pectin (producer: Grešík) and fibers (bamboo fiber: Natura Food Additives, a.s.) (according to Table 1), further 3 minutes jams were boiled. Experimentally produced jams undergone following analysis: fiber content, polyphenol content and textural parameters analysis. Fiber contents were determined according to ISO NORM.

**Table 1.** The composition of experimentally produced fruit jams.

| Samples | Fruit | Sugar | Pectin | Fiber |
|---|---|---|---|---|
| 1 | 400 g | 320 g | – | – |
| 2 | | | 2 % | – |
| 3 | | | – | 1 % |
| 4 | | | – | 5 % |
| 5 | | | – | 10 % |
| 6 | | | 2 % | 1 % |
| 7 | | | 2 % | 5 % |
| 8 | | | 2 % | 10 % |

The crude fiber content was evaluated by boiling 2 g of sample (weighed in fine lined pad) in 200 ml dilute sulfuric acid (1.25 %), for 30 minutes. The samples were then rinsed with boiling water and boiled again (for 30 minutes) in the digestion flask with 200 ml of boiling dilute NaOH (1.25%). After rinsing, the samples were dried at 105 °C and transferred in a muffle furnace at 600 °C± 20 °C for 1 hour. The samples were then weighed and calculated.

The total polyphenol content was evaluated with the use of Folin-Ciocalteau solution (diluted with water 1:10) and Na2CO3. The samples were diluted 100 times (with distilled water) and 1 mL of extract was used for analysis. Folin-Ciocalteau (5 mL) solution and 4 mL $Na_2CO_3$ (4 mL) were added and the samples were incubated for 30 minutes. The absorbance was measured at 765 nm (CECIL CE 7210 spectrophotometer), the standard solutions were different concentrations of gallic acid [11].

Texture analysis was performed by the TA.XT Plus Texture Analyzer (Texture Technologies Corp., Scarsdale, NY). The determination of the firmness (g), consistency (g sec), cohesiveness (g) and viscosity index (g sec) of jam samples were tested by the back extrusion rig. The rig consisted of a perspex base plate that was used to centrally locate sample container (50 mm internal diameter) beneath a disc plunger (150 mm long probe adapter). The samples were deposited into the sample container and a compressor test extrudes the product up and around the disc edge (35 mm). The test speed was 2.00 mm/seconds and the distance was 90.00 mm. Exponent Stable Micro Systems (version 6, 1, 11, 0, UK) software was used for the textural parameter determination.

Sensory analysis was provided by the trained panel consisted of twenty members, including male and female panelists. The sensory analysis was held at the Department of Plant Origin Foodstuffs Hygiene and Technology.

Statistical significance at p<0.05 was evaluated by oneway ANOVA analysis of variance, and parametric Tukey post hoc test (in the case when Levene's test showed equal variances p>0.05) and nonparametric Games–Howell post hoc test (in the case when Levene's test showed unequal variances p<0.05) for finding differences within groups. Overall differences among jam samples were checked by principal component analysis (PCA). SPSS 20 statistical software (IBM Corporation, Armonk, USA) was used.

## 3. RESULTS

Dry matter in fresh fruits and experimentally produced fruit jams are presented in Table 2. The amount of dry matter in the samples ranged from 65.38 ± 0.21% (apricot jam 1) to 77.67 ± 1.10% (currant jam 1) (the both samples were control samples without fiber addition). The highest measured dry matter was measured among redcurrant jams. Fresh redcurrants and apricots (apricots: 13.69 ± 2.79 %, redcurrants: 13.71 ± 0.19 %) had lower dry matter than cherries and sour cherries. Statistically significant (p < 0.05) differences were observed between apricot jam samples (samples 2, 3 and 6 had higher dry matter content than control sample: 1).

**Table 2**. Dry matter (%) in the samples of fresh fruits and prepared jams.

| Samples | Fruit jams | | | |
|---|---|---|---|---|
| | Apricots [%] | Redcurrants [%] | Cherries [%] | Sour cherries [%] |
| **Fresh fruit** | 13.69 ± 2.79 | 13.71 ± 0.19 | 15.87 ± 1.15 | 18.36 ± 0.53 |
| **1** | 65.38 ± 0.21$^{a}$ | 77.67 ± 1.10 | 69.24 ± 2.53 | 70.28 ± 0.22$^{ac}$ |
| **2** | 67.66 ± 0.12$^{b}$ | 75.03 ± 0.85 | 69.49 ± 0.25$^{a}$ | 71.32 ± 0.00$^{ab}$ |
| **3** | 67.43 ± 0.19$^{b}$ | 75.49 ± 0.28 | 65.57 ± 3.05 | 69.46 ± 0.17$^{ac}$ |
| **4** | 70.07 ± 0.59 | 77.19 ± 0.18 | 66.15 ± 0.70 | 73.84 ± 0.20$^{b}$ |
| **5** | 68.07 ± 0.83 | 74.00 ± 0.57 | 66.85 ± 0.21$^{b}$ | 72.28 ± 0.66 |
| **6** | 69.45 ± 0.25$^{b}$ | 76.54 ± 0.31 | 66.81 ± 0.14$^{b}$ | 69.56 ± 0.17$^{ac}$ |
| **7** | 68.74 ± 0.73 | 73.39 ± 1.63 | 66.69 ± 0.07 | 72.98 ± 0.12$^{b}$ |
| **8** | 67.24 ± 0.25 | 77.43 ± 0.61 | 68.66 ± 0.80 | 68.62 ± 0.10$^{c}$ |

Statistically significant (p < 0.05) differences were observed within cherries and sour cherries samples. As reported by USDA (2018), jams generally contain approximately 69.53% dry matter. This is corresponding to our results (Table 2). Dry matter values for fresh fruits, according to the database, are the following: apricot (13.65 %), currant (red, white) (16.05 %), cherries (17.75 %) and sour cherries (13.87 %) (USDA, 2018).

Sample 2 is considered a standard/control sample in the research. It was prepared according to the most often used fruit jam recipe (in the Czech Republic). Fiber contents ranged from 3.24 ± 0.05 % (sour cherry jams, sample 2) do 8.87 ± 0.44 % (apricot jams, sample 8). Among control samples (samples number 2) the highest fiber content had samples of cherry jams (5.14 ± 0.84 %). Among samples of fresh fruits, the highest content had samples of fresh redcurrants (7.77 ± 0.80 %), Statistical significant (p < 0.05) differences between control samples and fiber fortified samples were observed among apricot and sour cherry jam samples (Table 3).

Control samples (samples number 2) satisfy the requirement to be labelled as the source of fibre (at least 3 %), according to the European Regulation 1924/2006. The samples with 10 % addition of bamboo fibre (samples 8 and 5) fulfilled the regulation to be labelled as a high fibre source (at least 6 %). Dietary fibre intake is important as the prevention of constipation, hemorrhoids, hypercholesterolemia and colon cancer. The recommended daily dietary fiber is from 25 g to 30 g for adults. Certainly, fibers can interact with chemical compounds present in food. These interactions can lead to changes in nutrient bioavailability, the same as to textural and sensory changes of fortified products [12].

The total polyphenol content in the experimentally produced fruit jam samples ranged from 67.78 ± 0 mg/100 g (redcurrant jam, sample 5) do 161.95 ± 0 mg/100 g (apricot jam, sample 3), Samples with added bamboo fiber had mainly significantly (p < 0.05) lower total polyphenol content, especially in comparison with control samples 2 (Table 4). Polyphenols undergone degradation processes during fruit jam preparation, though authors observed very low changes of polyphenol content due to heat treatment [13]. Oppositely, another author found a significant reduction in polyphenol content during heating, as high as 93 % reduction [14]. The polyphenol content reduction was also noticed in fruit jam samples during storage period of 4 and 6 weeks; the reduction was up to 78 % [15].

**Table 3**. Crude Fiber content in the samples of fresh fruits and prepared jams.

| Samples | Fruit jams | | | |
|---|---|---|---|---|
| | Apricots [%] | Redcurrants [%] | Cherries [%] | Sour cherries [%] |
| **Fresh fruit** | 3.65 ± 0.09 | 7.77 ± 0.80 | 3.64 ± 0.16 | 3.65 ± 0.11 |
| **1** | 4.99 ± 1.17 | 3.52 ± 0.20 | 5.14 ± 0.84 | 3.47 ± 0.44 |
| **2** | 3.90 ± 0.37$^{ab}$ | 3.74 ± 0.16 | 4.90 ± 0.38 | 3.24 ± 0.05$^{b}$ |
| **3** | 4.63 ± 0.04$^{ac}$ | 4.22 ± 0.43 | 4.22 ± 0.13 | 3.82 ± 0.24 |
| **4** | 6.75 ± 0.45 | 5.06 ± 0.01$^{a}$ | 7.15 ± 0.93 | 5.22 ± 0.22 |
| **5** | 8.28 ± 0.32$^{cd}$ | 7.44 ± 0.95 | 8.73 ± 2.17 | 7.38 ± 0.08$^{a}$ |
| **6** | 4.09 ± 0.05$^{bd}$ | 3.85 ± 0.05$^{b}$ | 5.10 ± 0.12 | 3.81 ± 0.23$^{bc}$ |
| **7** | 6.29 ± 0.46 | 5.86 ± 0.33 | 6.72 ± 0.80 | 5.99 ± 0.13$^{c}$ |
| **8** | 8.87 ± 0.44$^{cd}$ | 8.03 ± 1.17 | 8.47 ± 1.45 | 5.99 ± 0.45 |

**Table 4**. Polyphenol contents in the samples of fresh fruits and prepared jams.

| Samples | Fruit jams | | | |
|---|---|---|---|---|
| | Apricots [%] | Redcurrants [%] | Cherries [%] | Sour cherries [%] |
| **Fresh fruits** | 96.38 ± 0.06$^{a}$ | 51.14 ± 0.10$^{b}$ | 51.47 ± 0.05$^{b}$ | 77.48 ± 0.03$^{c}$ |
| **1** | 142.65 ± 0$^{a}$ | 108.48 ± 0$^{a}$ | 91.05 ± 0$^{a}$ | 100.25 ± 0$^{a}$ |
| **2** | 140.48 ± 0$^{b}$ | 101.22 ± 0$^{b}$ | 103.23 ± 0$^{b}$ | 97.51 ± 0$^{b}$ |
| **3** | 161.95 ± 0$^{c}$ | 103.34 ± 0 | 87.62 ± 0$^{c}$ | 101 ± 0$^{c}$ |
| **4** | 116.73 ± 0$^{d}$ | 90.18 ± 0$^{d}$ | 92.07 ± 0$^{d}$ | 90.74 ± 0$^{d}$ |
| **5** | 129.54 ± 0$^{e}$ | 67.78 ± 0$^{e}$ | 82.72 ± 0$^{e}$ | 97.38 ± 0$^{b}$ |
| **6** | 118.93 ± 0$^{f}$ | 85.98 ± 0.$^{f}$ | 82.83 ± 0$^{e}$ | 95.16 ± 0$^{e}$ |
| **7** | 93.55 ± 0$^{g}$ | 76.27 ± 0 | 82.27 ± 0$^{f}$ | 90.37 ± 0$^{d}$ |
| **8** | 107.35 ± 0$^{h}$ | 73.17 ± 0$^{h}$ | 86.91 ± 0$^{g}$ | 82.37 ± 0$^{f}$ |

*different lowercase letters (a, b, c) are indicating statistical significant ($p < 0,05$) differences between fruits

The biological value of berries can be overviewed through their beneficial micronutrients content that includes polyphenol content. It should be stressed out that preservation of berries in products, such as jam, is an important part of human diet, since berries cannot be grown in the most regions and they are also seasonal food [16].

Principal component analysis (PCA) of experimentally produced fruit (apricots, recurrents, cherries and sour cherries) jams is shown in Figure 1. PCA included all measured parameters (dry matter content, polyphenol content, textural and sensory properties). Apricot and cherry jam samples showed the highest differences between jams with add bamboo fiber and jams without fiber fortification especially samples with 10 % of fiber addition (samples 5 and 8). Redcurrant and sour cherry jam samples showed lesser differences produced by fiber addition.

Figure 2 is showing sensory properties principal component analysis of experimentally produced fruit jams. It can be observed that 10 % and even 5 % of bamboo fiber fortification of fruit jams resulted in significant changes of fruit jam sensory properties. The samples produced with 1 % of bamboo fiber fortification had almost similar sensory characteristics as traditionally produced jams with the addition of sugar and 2 % pectin or not.

The overall sensory characteristics of fruit jams can be seen in Figure 3. It is undoubtedly clear that only 1 % of bamboo fiber fortification did not significantly affect sensory characteristics of experimentally produced jams.


**Figure 1**. Principal component analysis (PCA) of apricot, recurrent, cherry and sour cherry jams (dry matter content, polyphenol content, textural and sensory parameters).

* The compositions of experimentally produced fruit jams are shown in Table 1

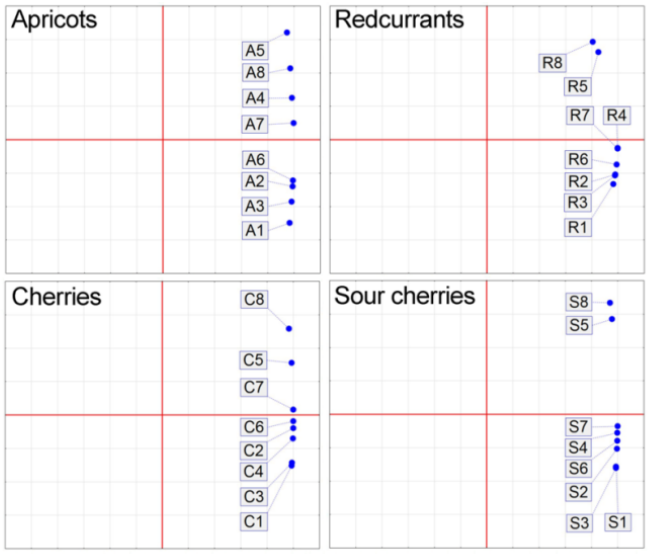


**Figure 2**. Principal component analysis (PCA) of apricot, recurrent, cherry and sour cherry jams sensory parameters.

*The compositions of experimentally produced fruit jams are shown in Table 1

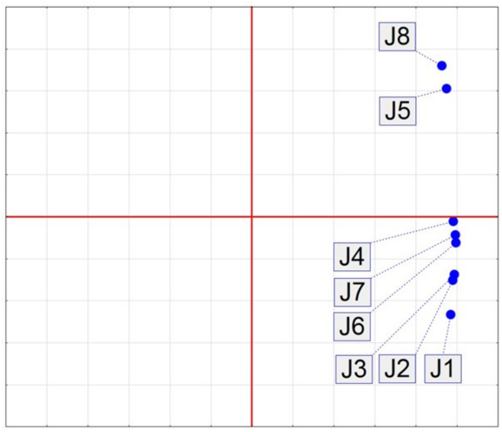


**Figure 3**. The overall principal component analysis (PCA) of apricot, recurrent, cherry and sour cherry jams sensory parameters

*The compositions of experimentally produced fruit jams are shown in Table 1

Apricots as fresh fruit, the same as processed, are very acceptable among consumers, since they have desirable aroma. Their shelf life is limited due to fast ripening, high respiration rate and soft texture. That is the reason why they are often processed into jams. These processing is making them available on the market throughout the year [17,18].

The biological value of berries can be overviewed through their beneficial micronutrients content that include polyphenol content. It should be stressed out that preservation of berries in products, such as jam, is an important part of human diet, since berries cannot be grown in most regions and they are also seasonal food [16]. Phenolic compounds occur as secondary metabolites in fruits, vegetables and whole grains. These compounds derived from phenylalanine and tyrosine are known radical scavenger and are broadly used in the food industry due to their capability to inhibit oxidative degradation of lipids [19]. On the other hand, it is still not fully understood the process of phenolic compounds degradations, during storage or heating processes, in food matrixes [20].

Due to worldwide jam consumption, there is a chance to use fruit jams as delivery vehicles for functional components that have physiological benefits (causing reduction of certain ailments). On the other hand sensory characteristics should not be changed significantly since in that case there is a higher chance of consumers not acceptance [21].

## 4. CONCLUSIONS

The study showed how bamboo fiber fortification affects nutritional, textural and sensory characteristics of experimentally produced jams. The study included 4 different fruits (apricot, recurrent, cherry and sour cherry); giving relevance to obtained results and conclusion. The gained results unambiguously showed that 5 % and 10 % of bamboo fiber addition resulted in significant changes in measured parameters. Especially sensory properties were affected. These findings can be useful for future studies, the same as for the industrial practical application.

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