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Determination of Crude Fiber Content and Total Sugars in Correlation with the Production Process and Storage Time

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ABSTRACT

In this original scientific paper, the content of crude fiber and total sugars in three different fruit products (cherry compote, rosehip marmalade and plum jam) in correlation with the production process and storage time was examined. All tests were conducted in the Laboratory of Food Technology, Faculty of Technology, University of Tuzla. The test results showed that in all fruit products a higher content of non-reducing sugars than reducing and sucrose was recorded. Also, the highest content of crude fiber was obtained in the S5 sample for rosehip marmalade and was 1.11%, while the lowest was recorded in the S1 sample for cherry compote and was 0.011%.

Keywords- crude fiber, total sugars, compote, marmalade, jam.

I. INTRODUCTION

Fruits, as well as fruit products, play a very important role in human nutrition. However, a large number of different types of fruit are not available to consumers throughout the year, mostly due to the lack of storage capacity and expensive transport in cold stores [1]. Therefore, today a large number of fruit products are produced both industrially and at home.

Commercially, the two most important cherry species are: sweet cherry, (*Prunus avium, L.*) and sour cherry, (*Prunus cerasus L.*), both tree fruits native to southeastern Europe and western Asia [2]. Sweet cherry (*Prunus avium L.*) is one of the most popular and appreciated temperate fruit not only for its sensory and nutritional properties, but also for its content in bioactive compounds [3]. Some of the bioactive components present are anthocyanins, quercetin, hydroxycinnamates, potassium, fiber, vitamin C, carotenoids, and melatonin [4]. Thus, sweet cherries derived extracts are crucial in free radical scavenging, cell oxidative injury protection, anti-inflammatory action, anti-tumor proliferation and alleviation of diabetic complications among others [5].

Rosehip, a wild fruit which is used more often recently to produce mark, jams and juices [6]. The consumption of rosehip fruits, flowers, leaves and buds prevents and combats diseases including skin disorders, hepatotoxicity, renal disturbances, diarrhoea, inflammatory disorders, arthritis, diabetes, hyperlipidaemia, obesity and cancer [7]. Rosehips contain more and a greater variety of phytochemicals compared to other fruit species. Also, they contain minerals, high-capacity antioxidants, carotenoids, phenolic compounds, tocopherol, bioflavonoids, tannins, pectins, organic acids, amino acids, ascorbic acid, and fatty acids [8].

Wild plums as a source of food and medicine for thousands of years [9]. The fruits of plum (*Prunus domestica L.*) have long been consumed as fresh, dried or processed for human consumption [10]. Plums are a raw material rich in biologically-active substances with antioxidant properties, which is correlated with high contents of phenolic compounds, with the predominance of derivatives of caffeic acid, mainly neochlorogenic and chlorogenic acids, together with smaller amounts of anthocyanins, flavanols and flavonols [11]. The postharvest life of plum fruit is relatively short, up to 2 weeks in a cold atmosphere [12]. Therefore, they are processed from plums into products such as prunes, jams, compotes or juices. Various fruit products are consumed throughout the year: juices, compotes, jams, marmalades, sweets, jams, jellies and other products. In our conditions, the fruit season begins with strawberries, cherries, peaches, apricots, and ends with winter varieties of apples and pears [13].

Jams are delicious and nutritious spreads typically made from fruit, sugar and pectin that ensure availability of fruits in off-season [14].

Compote is a product with whole fruits or parts of fruits in sugar syrup, preserved by pasteurization in hermetically sealed packaging. It can be produced from almost all fruit gardens, but stone fruits are especially suitable: cherries, cherries, plums and apricots, and pears and quinces from apple fruits. It can be only one type of fruit, or more - mixed compote.

Marmalade is a gelled product obtained by cooking fresh, frozen or temporarily preserved canned fruit with the addition of sugar, pectin and acid. It is mainly produced from semi-finished products (90%) and less (10%) from fresh fruit. Marmalade is a homogeneous product, firm in consistency and can be spread or cut. It can be produced from one or more types of fruit. Determination of sugar in fresh fruit is a very important indicator of quality and maturity [15].

The main objective of present study was to analyze the content of crude fiber and total sugars in selected types of fruit products in correlation with the production process and storage time. The authors define "crude fibre" as the sum of cellulose (60-80%), pentosans and lignin (4-6%) remaining after an empirical treatment with enzymes designed to remove protein, digestible carbohydrates and any small quantity of lipid material. Crude fiber also has pivotal role in human diet, because their consumption has been related to decreased incidence of several diseases such hemorrhoids, diverticulosis, coronary heart diseases, and some type of cancer [16], [17], [18]. On the other hand, crude fiber can prevent the absorption of harmful substances in the body [19].

The most important components of the chemical composition of fruits and vegetables are considered to be sugars, acids, dyes, pectin and minerals [20 a].

Sugars are the most common ingredients after water. They make up the largest part of soluble dry matter, which is determined as a refractometric value. Together with acids, they represent a basic component in the formation of product taste. The content of total sugars varies in a very wide range, which depends on the type, variety, degree of maturity as well as growing conditions. Monosaccharides make up the majority of sugar in fruits. Glucose from monosaccharides predominates in stone fruit, but there is also a significant amount of sucrose [20 b].

The ratio of invert sugar and sucrose in fruit varies by species and varieties. It can generally be said that the predominant part of the sugar in the fruits consists of monosaccharides. Thus e.g. in grapes, sugar is in the form of monosaccharides, about 50% glucose and about 50% fructose, but this ratio is not constant during ripening Glucose from monosaccharides predominates in stone fruit, but there is also a significant amount of sucrose.

II. MATERIALS AND METHODS

The primary goal of this paper is to investigate the quality of fruit products in correlation with the production process and length of storage, testing the content of crude fiber and carbohydrates.

Materials

Raw materials

Different types of different fruit products were used as samples for this research. The products are packed in the same 720 mL packaging units and are cherry compote, rosehip jam and plum jam. These products have different production dates at intervals of several months.

Chemicals

The following analytical grade reagents were used during the analysis:

Methods

Determination of crude fiber

Determination of crude fiber in samples of cherry compote, plum jam and rosehip marmelade was performed by the Kűrschner-Hanak method [21 a]. During the analysis, measure 1,000 g of the finely chopped sample and place in a 100 mL flask, then add 25 mL of 80% acetic acid and 2.5 mL of concentrated nitric acid and cook for half an hour under reflux. After cooking, it is still hot filtered through a dried and measured 1-G-3 filter crucible with weak evacuation. The precipitate is first washed with about 10 mL of a hot mixture of acetic and nitric acid, then with hot water and finally with ethanol and ether. Dry for 30 minutes in an oven at 105 °C, cool and measure quickly.

The crude fiber content is calculated according to the formula:

Crude fiber content (%) = a*100 /Ok

Where are they:
a - measured amount of crude fiber (g)
Ok - measured quantity of sample taken for analysis (g)

Determination of carbohydrates

Determination of carbohydrates in fruits and fruit products obtained in the experimental part of this paper was done by the standard volumetric method according to Luff Schoorl [21 b]. This method is suitable because during prolonged cooking with Luff's solution glucose and fructose show the same reducing ability, so the same calculation table can be used for glucose and fructose, and thus for invert sugar.

Preparation of the basic filtrate:

To prepare the basic filtrate, it is necessary to prepare Carrez clarification reagents (Carrez I and Carrez II), and the procedure is carried out as follows: 2-10g (depending on the sugar concentration) of the sample for analysis is measured in measuring vessel and quantitatively transfer to a beaker, dilute with hot water and, if necessary, heat on a water bath, with occasional shaking, until the mass becomes homogeneous. It is then quantitatively transferred via a funnel to a 100 mL

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volumetric flask, allowed to cool and made up to the mark. It is filtered and it is a basic solution. Transfer 50 mL of stock solution to a 250 mL volumetric flask and add Carrez clarifying reagent (add the same volumes of solution I and solution II). Add 2 mL (or 5 mL) of 15% potassium iron (II) cyanide solution (Carrez I) first, followed by 2 mL (or 5 mL) of 30% zinc sulfate or zinc acetate (Carrez II) solution. Stir, make up to the mark with distilled water, mix well and filter (blue stripe filter paper). The basic filtrate thus obtained is used for the determination of sugar.

Procedure for determining sugar before inversion:

Pipette 25 mL of Luff's solution into a conical flask with a 300 mL ground stopper, add as much sugar, which should generally contain 10-60 mg of sugar (10-25 mL of basic filtrate), and then so much water that the total volume be 50 mL. It is heated directly on the Bunzen burner so that boiling starts after 2 minutes. To make boiling more correct, add a few floats. When the solution has boiled the erlenmayer is connected to the reflux condenser and heating on the asbestos mesh is continued. From the moment of boiling, cook for exactly 10 minutes. A blank (with 25 mL of Luff's solution and 25 mL of distilled water) was placed in parallel with the analysis (main sample). After cooking, the erlenmayer is cooled under running water and after 5 minutes the sugar is determined by titrating the excess unreduced Cu^{2+}.

Determination of unreduced copper (II) ion

Principle: copper ions (excess Cu^{2+}) are determined by the addition of potassium iodide in an acidic environment:

$$2Cu^{2+} + 4J^{-} \rightarrow Cu_2J_2 + J_2$$

(by adding KJ in excess the reaction flows to the right)

$$J_2 + NaS_2O_3 \rightarrow 2NaJ + Na_2S_4O_6$$

The difference in mL of 0.1 mol/L $Na_2S_2O_3$ solution used for the blank (total Cu^{2+}) [21 c].

Procedure: to the cooled solution, after precipitation of Cu_2O, add about 3 g of KJ (or 9 mL of 1 mol/L KJ solution) and very carefully, little by little 25 mL of 25% sulfuric acid solution. The separated iodine is titrated with 0.1 mol/L $Na_2S_2O_3$ solution until the color of the solution turns yellow, then 1 mL of starch solution is added and further titrated until the color turns blue to pale yellow.

The content of reducing sugars is calculated according to the formula:

Reducing sugar content = (amount of sugar corresponding to sodium thiosulphate consumption x 100)/100

Sugar reduction process after inversion

In 50 mL of basic filtrate, non-reducing sugars were hydrolyzed by the addition of 5 mL of concentrated HCl and boiled for 10 minutes in a water bath at 70 °C. After cooking, the solution was neutralized with NaOH (pH = 6) with methyl orange and made up to 100 mL with water. Take 10 mL of the inverted solution for the determination of sugar and proceed in the same manner as for the determination of sugar before inversion.

The content of total sugars is calculated according to the formula:

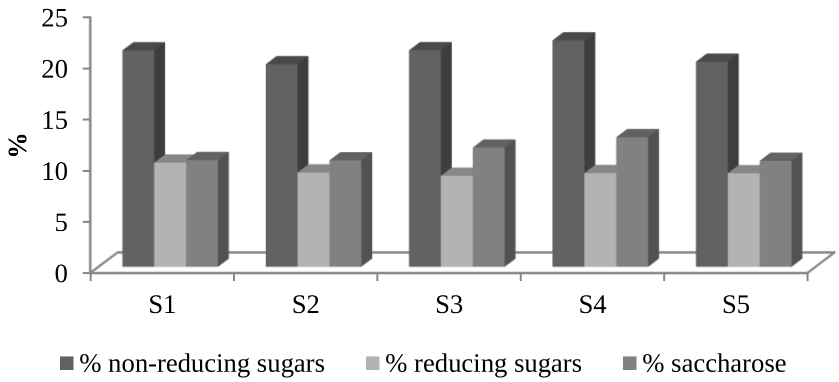
Reducing sugar content = (amount of sugar corresponding to sodium thiosulphate consumption x 100)/100

and the invert sugar content according to the formula:

Invert sugar content = total sugar content - reducing sugar content

III. RESULTS AND DISSCUSION

All the results of the analysis of the tested samples are presented graphically, and are expressed as the mean values of three repeated measurements for each tested parameter. Samples of tested fruit products are marked with abbreviations S1 (sample 1), S2 (sample 2), S3 (sample 3), S4 (sample 4), S5 (sample 5).



Graph 1. Results of determination of total sugars (%), cherry compote

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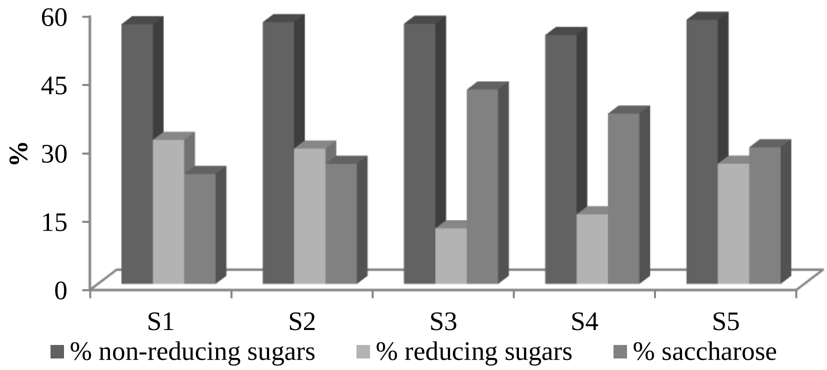
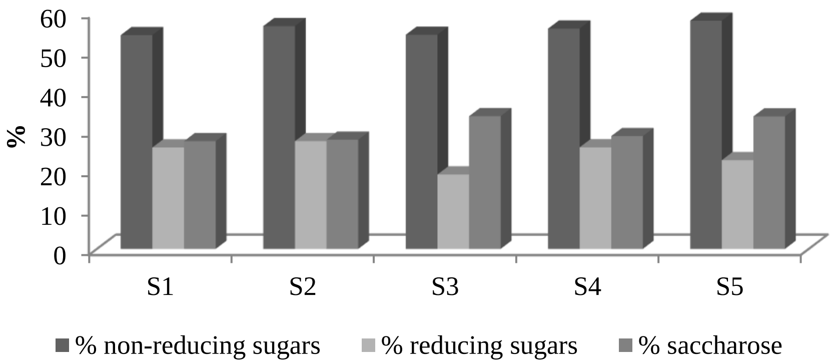
Samples of cherry compote were produced in different time intervals: S1 (20.05.2015), S2 (13.01.2016), S3 (24.04.2016), S4 (23.06.2016), S5 (02.11.2016). From the presented results (Graph 1.) of total sugars (%) in cherry compote, the higher content of non-reducing sugars in all samples than reducing sugars and sucrose is clearly visible. The highest content of non-reducing sugars was recorded in S4 (22.13%), while the lowest was in S2 (19.79%). The content of reducing sugars had an average value for all samples of 9.32%, and the highest content was recorded in S1 (10.18%), while the lowest was in S3 (8.89%). The sucrose content had values slightly higher than the reducing sugars, so the highest sucrose content was recorded in S4 (12.66%), while the lowest was S5 (10.36%). Tural and Koci, 2008 are reported that cornelian cherry fruits (*Cornus mas L.*) grown in Turkey contents of total sugars 93,42 ± 18,67 g/kg, reducing sugars 81,80 ± 16,83 g/kg and non-reducing sugars 11,03 ± 9,05 g/kg [22].



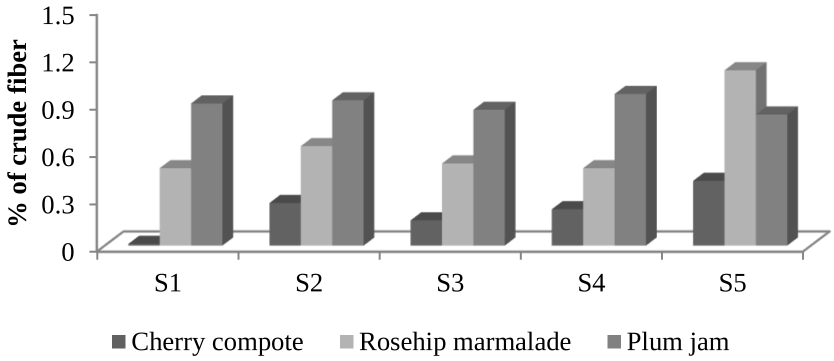
Graph 2. Results of determination of total sugars (%), rosehip marmalade

Graph 2. presents the results of the total sugar content (%) for the sample of rosehip marmalade. Samples of rosehip marmalade were produced in different time intervals: S1 (17.02.2015), S2 (20.10.2015), S3 (19.03.2015), S4 (08.09.2016), S5 (28.11.2016). As with cherry compote, rosehip marmelade showed a higher content of non-reducing sugars in all samples compared to the content of reducing sugars and saccharose. The highest content of non-reducing sugars was recorded in S5 (57.91%), while the lowest was recorded in S3 (57.05%). Furthermore, the content of reducing sugars was highest in S1 (31.58%), while the lowest was S3 (12.19%). The highest sucrose content was recorded in S4 (37.35%), and the lowest was in S1 (24.11%). Yildiz and Alpaslan, 2012 reported that the content of reducing sugars was 22.9 ± 0.90 in rosehip marmalade produced by the classical method [23 a].



Graph 3. Results of determination of total sugars (%), plum jam

Samples of plum jam were produced in different time intervals: S1 (14.01.2015), S2 (10.03.2015), S3 (28.03.2016), S4 (15.09.2016), S5 (12.01.2017). The content of total sugars (%) is presented in Graph 3. for plum jam. In accordance with the results for the previous two fruit products (cherry compote and rosehip marmalade), the highest content of non-reducing sugars was observed in this fruit product as well. Thus, the highest content of non-reducing sugars was recorded in S5 (57.76%), while the lowest was in S1 (54.10%). The content of reducing sugars was the highest in S2 (27.28%) and the lowest in S3 (18.84%). The highest sucrose content was recorded in sample S3 (33.60%), while the lowest was in S1 (27.28%). Pashova reported that total sugar content is 8.76% to 15.36% in fresh plum fruit [24].



Graph 4. Results of determination of crude fiber for tested fruit products

The results of crude fiber content in cherry compote samples had significantly lower values compared to other fruit products such as rosehip marmalade and plum jam. Thus, the lowest content of crude fiber was in S1 (0.01%), while the highest content was in S5 (0.41%). In resehip marmalade, the highest content of crude fiber was in S5 (1.11%), while the lowest content was recorded in S1 and S4 (0.49%). Yildiz and Alpaslan, 2012 reported that the content of pectin in rose hip fruits was 4.1 ± 0.03%, while the content of pectin in marmalade produced by the classical method decreased to 0.028 ± 0.04% [23 b]. Plum jam had approximately the same crude fiber content in all 5 samples. It should also be noted that the plum jam has preserved the higher the amount of vitamin C during processing and storage, as well as the content of polyphenolic compounds [25]. However, the highest content was recorded in S4 (0.96%), while the lowest was S3 (0.86%). Ajenifujah-Solebo and Aina, 2011, reported that the crude fiber content in black plum jam 1.0 ± 0.03% [26]. One of the factors influencing the content of crude fiber in fruit products is the ripeness of the fruit, especially pectin, one of the sources of fibers hydrolyzed during ripening which is used for production [27]. The content of soluble pectin in plums by years, shows that in 2011 they contain 0.79% soluble pectin's, in 2012 0.80%, and in 2013 0.78%, while the values are lower than 0.714% [28].

IV. CONCLUSION

Based on the conducted research, it can be concluded that cherry compote, marmalade rosehip and plum jam are rich in raw plant fibers and total sugars. The influence of the length of storage on the content of total sugars and crude plant fibers did not have significant deviations in fruit products.

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