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Antioxidant Activity of Tomato Powder Dehydrated at Different Temperatures

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ABSTRACT

In this scientific research, tomato powder was obtained from two tomato varieties, Pink rock and Big beef, by drying in a dehydrator at two temperatures, namely 50 and 75 °C. The results showed that tomato powder is very rich in phytochemicals, such as lycopene, vitamin C, total phenols. The highest content of vitamin C (mg/100 g of dry matter) was in fresh tomatoes compared to tomato powder, because vitamin C is thermolabile. On the other hand, the highest content of total phenols was 62.916 mg/100 g dry matter, lycopene whose value was 66.6 mg/100 mg, FRAP 4868.75 µmol Fe/100 g sample in tomato powder dried at 75 °C. Therefore, it can be concluded that tomato powder is rich in antioxidants and that it is recommended in the diet of people when the weather conditions are not suitable for the consumption of fresh tomatoes.

Keywords : Antioxidant Activity, Different Temperature, Tomato Powder

I. INTRODUCTION

Today, when the great economic crisis in the world is a daunting task for the whole world, food and nutrition security for more than 9 billion people will be ensured [1]. Food of plant animal origin and in some cases from some microorganisms by biotechnology methods is essential for human survival and development at all times It contains moisture, protein, lipid, carbohydrate, minerals, and other organic substances. Humans can consume food in raw or canned form in order to provide themselves with energy and growth [2], [3a]. Therefore, the main task of today's food technology engineers is to make food that can be said to consist of "edible biochemicals" safer and more accessible to the general population, whether it is used fresh or canned [4]. Growing, harvesting, processing, packaging, and distribution of foods are methods which include food preservation [3b]. The term food preservation refers to the process of handling and processing food to control its spoilage by stopping its attack and growth diseases caused by food-borne microbes; to avoid fat oxidation (rancidity) and to maintain the nutritional value, texture and taste of food [5]. The application of techniques that include traditional and modern methods is resorted to to eliminate contamination with microorganisms and to avoid rancidity of fats present in food [6]. Mostly these techniques are based on physical phenomena that include heat transfer, moisture removal and prevention of enzymatic and chemical reactions [7]. Fresh tomato fruits containing in bioactive compounds are perishable under natural conditions [8]. Therefore, in this scientific research work, the drying method was used as a preservation method in order to reduce the enzymatic activity and water activity. Drying food is one of the oldest methods of food preservation and is a method that people have used for thousands of years to preserve food and remove liquid from raw materials [9a]. Preservation by drying is still based on empirical research, not on facts and proven theories [9b]. This process is used to produce microparticles or powders from aqueous solutions or suspensions that act as ingredients, carriers or final products. Powdered food is mainly intended for rehydration in liquid [10]. To preserve tomato for a longer duration and to ensure their easy availability for off-seasonal use without considerable deterioration in nutrient levels, an appropriate drying method is essential for the removal of moisture to a safe activity value [11]. In addition to preservation, the reduced weight and bulk of dehydrated products decreases packaging, handling, and transportation costs. Furthermore, most food products are dried for improved milling or mixing characteristics in further processing [12]. The lack of dehydration process is a technological challenge due to the very low level of moisture, the maximum stability of the product is not easy to achieve with minimal changes in food materials [13]. Tomatoes are one of the main ingredients of the Mediterranean diet, but they are also represented in the Continental diet, which is represented in the northern part of Bosnia and Herzegovina, where the research was carried out. Tomato fruits are very rich in lycopene, phenols and polyphenols, which are good for the health of consumers [14]. Tomatoes can be divided according to color, growth type, leaf, blossom, flower, fruit shape, productivity, fruit size, fruit consistency and ripening [15]. In this original scientific paper, two varieties ("Pink Rock" i "Big Beef") of tomatoes from a local store were used. Extremely fertile, highly resistant to diseases and has a very pleasant smell and taste, and customers are increasingly looking for this variety. It is an indeterminate (tall) variety that is an early hybrid of pink color, with uniform fruits whose individual weight often exceeds 300 grams, so over 10 kg can be harvested per stem. Due to the large fruits and high yields, the stem must be tied up to two or three places along the tree to prevent it from cracking and breaking. Tempting due to its size, juicy and fleshy fruit, pleasant smell and taste, the Pink Rock rose is currently the most sought after in markets and markets, and both sellers and customers are satisfied. Due to continuous and high demand, this variety is profitable, producers and sellers achieve acceptable selling prices. Unpredictable weather conditions and a much more difficult outdoor protection procedure are, for most farmers, one of the reasons why they shift production to greenhouses. Weather protection and control in a protected area create ideal conditions for the cultivation of Pink rock, whose yields, with good agrotechnical measures, can reach up to 1500 kg per 100 m^2. [16] Big Beef F1 is an early indeterminate beef-type tomato. The plants are healthy and strong. Due to its quality, it is a favorite among producers who do their own sales at the counter. The fruits are large, oval, red in color, with excellent taste and medium firmness. Early maturity combined with large fruits and excellent disease resistance make Big Beef F1 a hybrid suitable for different production conditions. 'Big Beef F1', also known as Big Beef Tomato. 'Big Beef F1' is a bushy variety that can reach 250 cm in height. But outdoors, they are usually smaller: around 150 cm. The fruits of 'Big Beef F1' are round to flattened, slightly ribbed and bright red when fully ripe. They weigh around 350 to 400 grams and therefore belong to the group of large-fruited beef tomatoes. The fruits ripen in high fertility from the beginning to the middle of August. With a pleasant flavor that balances sweetness and acidity, this variety is resistant to two strains of *Fusarium*, *Verticillium*, *Alternaria*, *Tobacco Mosaic Virus* (TMV) and nematode infestation [17], [18].

In this paper, the influence of drying temperature on the antioxidants of tomato powder obtained under laboratory conditions was investigated. The following antioxidant activity of tomato powder were investigated: vitamin C, total phenols, lycopene, FRAP and DPPH.

II. METHODS AND MATERIAL

Technological procedure for obtaining tomato powder

As already mentioned in the previous chapter, two varieties of tomatoes, Pink Rock and Big beef, were used. From these two varieties of tomatoes, tomato powder was prepared by a not so simple technological process that includes actions such as: inspection of tomato fruits, which includes sorting and removing all tomato fruits that do not meet quality criteria. Then follow the operations of washing with clean drinking water and sorting the fruits into plastic open crates. The tomato fruits were cut into thin slices whose thickness did not exceed 1 cm, they were dried in a dehydrator at two temperatures, 50 and 75 °C. After the heat treatment of the tomato fruits, the samples were cooled to room temperature in a dark place and the tomatoes were ground to a certain granulation. The resulting tomato powder was then stored in hermetically sealed jars in a dark place at room temperature until the chemical analysis of phytonutrients. Dehydration of fresh tomatoes was carried out at two temperatures: 50 °C and 75 °C, and the samples were marked as follows: PR50 and PR75 - Pink rock variety dehydrated at 50 °C and 75 °C and BB50 and BB75 – Big beef variety dehydrated at 50 °C and 75 °C. A dehydrator, Adler, Europe, AD 6655 was used to obtain tomato powder.

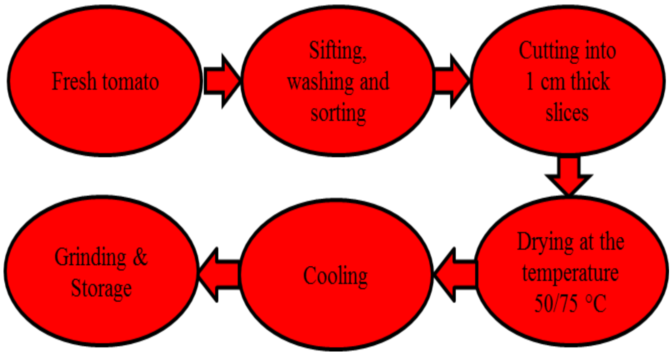

Figure 1. Technological procedure for obtaining tomato powder

Determination of vitamin C (mg/100 g dry matter)

Blend 3 g of ground tomato sample with 10 mL of 2% oxalic acid. Transfer the suspension to a 100 mL measuring cup and add up to the mark with 2% oxalic acid solution. Then pipette out an aliquot of the sample and titrate with 2.6 dichlorophenol-indophenol until a pink color appears, which must be maintained for 15-20 seconds.

Determination of total phenols (TS, mg GAE/100 g sample)

Total phenol content was determined spectrophotometrically, using the Folin-Ciocalteau method [19] with gallic acid (99% purity, Sigma) as a calibration standard. Tomato samples were extracted with methanol. After extraction, each of the tomato methanol extracts were mixed with Folin-Ciocalteau reagent and sodium carbonate solution (20% w/v). After incubation, the reaction mixture was diluted with distilled water to the final volume. The absorbance at 765 nm was measured for each mixture on a spectrophotometer after incubation for 60 min at 23° C. The instrument used in this research is the UV-1800 CE 230V, Shimadzu.

Determination of lycopene (mg/100 g sample)

The lycopene content was extracted by mixing 1g of tomato sample with 15 mL of acetone-hexane solution in a ratio of 4:6. The absorbance of the filtrate containing this pigment was then measured at 663, 645, 505 and 453 nm with a spectrophotometer at the same time. The instrument used in this research is the UV-1800 CE 230V, Shimadzu. The formula for calculating the lycopene content is as follows: Lycopene (mg/100 g sample) = - 0.0458 × A663 + 0.204 × A645 + 0.372 × A505 - 0.0806 × A453 [44].

Determination of antioxidant activity *(FRAP, µmol Fe/100 g sample)*

The FRAP (Ferric Reducing Antioxidant Power) method is based on the extract's ability to reduce F^{3+} ions to F^{2+} ions. The resulting F^{2+} ions with the TPTZ reagent (2,4,6-tri(2-pyridyl)-s-tyrazine) form a blue colored complex. The change in absorbance is directly related to the combined or "total" reduced power of the electron-donating antioxidants in the reaction mixture. Ferrous sulfate solution is used as a reference solution [20 a]. First of all, FRAP reagent was prepared by mixing acetate buffer + TPTZ reagent + $FeCl_3$ $6H_2O$ in a ratio of 10:1:1. The FRAP reagent is stored in a water bath at 37°C until use. In the process of determining the antioxidant activity, the extract in the amount of 0.1 mL was mixed with 3 mL of FRAP reagent. The absorbance at 593 nm was measured for each sample on a spectrophotometer (UV-1800 CE 230V, Shimadzu) after incubation for 30 min at 37° C. The concentration (mmol/L) of Fe^{2+} in the sample was determined from the equation of the calibration curve.

Determination of DPPH radical scavenging activity (IC50, mg/mL)

DPPH (2,2-diphenyl-1-picryl-hydrazyl) is a stable, purple colored nitrogen radical. The antioxidant activity of the sample was determined by measuring the ability to inhibit the free 2,2-diphenyl-1-picryl-hydrazyl (DPPH) radical. The antioxidant capacity is measured in the form of hydrogen release by the antioxidant, i.e. the ability to bind radicals, where the stable DPPH radical is used. The free radical removal reaction is followed by a color change from intense purple at the beginning of the reaction to yellow, which is detected by a decrease in absorbance at the specified wavelength. The ability of antioxidants to reduce the DPPH radical is monitored by measuring the change in absorbance at 517 nm [20 b]. A certain amount of methanol in the range of 1 to 3.5 mL is added to previously filtered and diluted samples of chopped tomatoes in the volume range of 0.5 to 3 mL in a test tube. After homogenizing the solution with methanol, the samples are incubated for 30 minutes in a dark place at room temperature. After incubation, the absorbance is measured at 517 nm. As a mandatory analysis, a blind test is also prepared, which represents the control. Fill the test tube with 4 mL of methanol and 1 mL of 0.5 mM DPPH solution.

III. RESULTS AND DISSCUSION

Results of Vitamin C (mg/100 g dry matter) of fresh tomato and tomato powder dehydrated at 50 °C and 75 °C

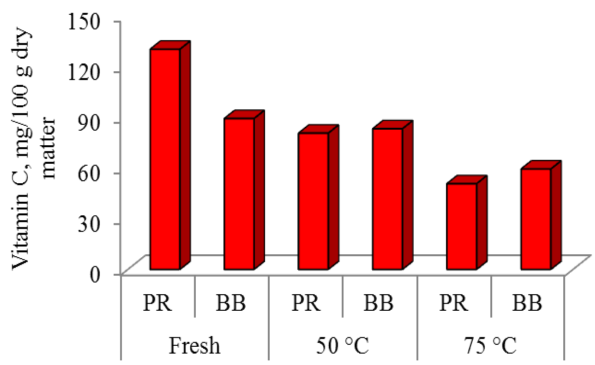

Figure 2. Vitamin C (mg/100 g dry matter) of fresh tomato and tomato powder dehydrated at 50 °C and 75 °C

Beecher, 1998 reported that tomatoes and tomato products are rich in vitamin C [21]. The content of vitamin C (ascorbic acid) in fresh tomatoes was for sample PR 130.2 mg/100 g dry matter, and for sample BB this value was 89.23 mg/100 g dry matter. Gumel et al. 2012 reported that the vitamin C content was 395.45 mg/L for fresh tomatoes, while for dried tomatoes this value was 60 mg/L [22]. Duma et al. 2015, examined the content of vitamin C during ripening in different varieties, and noted that the highest content of vitamin C was recorded in the variety Sunstream in the red stage [23]. Tomato powder had vitamin C values in both samples of around 80 mg/100 g dry matter at a drying temperature of 50 °C, however, further increasing the temperature to 75 °C in both samples resulted in a drop in vitamin C values to 50.67 mg/100 g dry matter for PR and 59.38 mg/100 mg dry matter for BB sample respectively. Adejo et al. 2015 reported that the content of vitamin C in tomato powder samples varied depending on the drying method. Thus, the sun-drying samples had values of 17.78-28.44 μg/mL, while the oven- and solar-dried samples had higher vitamin C content values in the range of 100.15 ± 1.03 μg/mL to 164.74 ± 2.06 μg/mL, respectively [24].

Results of total phenols (TS, mg GAE/100 g sample) of fresh tomato and tomato powder dehydrated at 50 °C and 75 °C

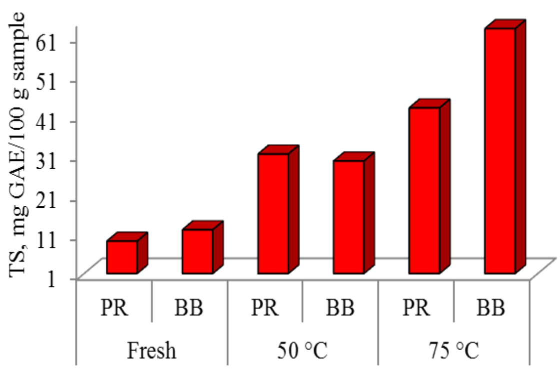

Figure 3. Total phenols (TS, mg GAE/100 g sample) of fresh tomato and tomato powder dehydrated at 50 °C and 75 °C

Phenols are good electron donors because their hydroxyl groups can directly contribute to antioxidant action [25]. Tomato polyphenols, mainly phenolic acids, are present in free soluble form and in insoluble form when they are they are tied to the fiber [26]. Phenolic acids are mainly divided in to two sub-groups: hydroxybenzoic and hydroxycinnamic acid [27]. The content of phenolic compounds in tomato products is almost the same as in fresh tomatoes, however, due to the influence of the tomato variety and origin, the content of total phenols is variable in the final product [28]. In this study, the initial content of total phenols expressed as mg GAE/100 g sample in both tomato varieties was lower than in tomato powder. The highest content of total phenols was recorded in sample BB and amounted to 62.916%. Capanoglu et al. 2010 in their work stated the total phenolic content increased by 13% and 50% in dried tomato respectively, when compared to the corresponding levels in fresh tomatoes [29]. Nour et al. 2013 determined the total phenolic content in fresh tomato varieties and these values ranged from 31,22 mg GAE/100g to 55,78 mg/100g [30]. According to Ilahy et al. 2011, the content of total phenols ranged from 10.58 mg GAE/kg fresh weight in cv Lyco 1 to 39.4.5 mg GAE/kg [31]. Based on this, it can be concluded that the obtained values of total phenols in this work were within the limits of scientists Nour et al. Hdideret al. 2012, investigated the influence of the stage of maturity of high-lycopene varieties on the content of phenolic compounds in their work and came to the result that the ripe tomato fruit had values of total phenols from 10.5 to 39.4 mg GAE/100 g sample [32].

According to Butt et al. 2020 production of tomato powder does not significantly lose its nutritional properties, which is also confirmed in its results, where the TPC content (mg GAE/g) was analyzed in the control fresh sample, which was 19.3, and dehydrated samples at different temperatures, whose values were higher. Thus, at a drying temperature of 180 C, a TPC value of 2.15 mg GAE/g was recorded [33]. Vallverdú-Queralt et al. 2011 investigated the influence of the drying regime on the content of phenolic compounds in diced tomatoes varied from 320.8 ± 7.1 mg GAE/100 g dry matter for the final product after cold treatment to 138.2 ± 4.2 mg GAE/100 g dry matter for diced tomatoes subjected to hot treatment [34]. It should be underlined that higher values of phenolic compounds were recorded in high-lycopene varieties compared to ordinary varieties which are used in this paper [35]. Despite the antioxidant activity, they have many other beneficial effects on human health [36]. The dietary intake of phenolics positively correlates to a reduced incidence of many chronic pathologies, including cardiovascular, neurodegenerative and neoplastic diseases [37].

Results of lycopene (mg/100 g sample) of fresh tomato and tomato powder dehydrated at 50 °C and 75 °C

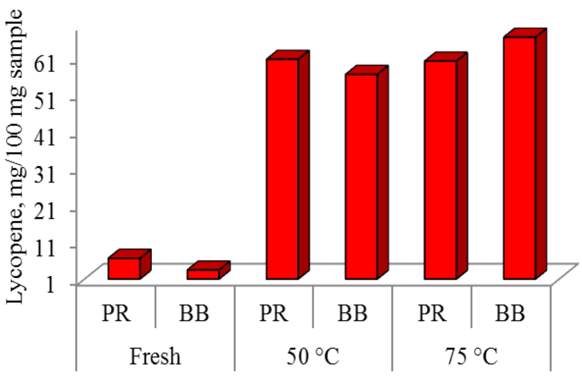

Figure 4. Lycopene (mg/100 g sample) of fresh tomato and tomato powder dehydrated at 50 °C and 75 °C

Lycopene as the main natural antioxidant in fresh tomatoes and tomato powder content also accounts for the redness, which is one of the main qualities in industry and consumers now look at. This antioxidant is responsible for the red color of tomatoes and tomato products, which affects the very total quality and sales [38]. The content of lycopene in fresh tomatoes depends on several factors, such as the variety and degree of ripeness of the fruit [39]. More than 80% of the dietary lycopene intake comes from the consumption of tomato products, including raw tomatoes, tomato juice and tomato sauces [40]. The important role of lycopene in human health is reflected in the fact that it reduces the risk of cardiovascular diseases as well as cancer topology by it exhibits the highest physical quenching rate constant with singlet oxygen [41]. Górecka et al. 2020 reported that highest lycopene content was in tomato paste (184.29 and 211.73 mg/100 g dry matter). Furthermore, in the same paper Górecka et al. reported that the lycopene content of fresh tomatoes is 53.21 mg/100 g dry matter or 2.94 mg/100 g of the product, which agrees with the data of other scientists who reported that the lycopene content of fresh tomatoes is in the interval of 0.88 to 7.74 mg/100 g of product [42]. In this research work, the lycopene content was between 3.46-6.63 mg/100 g sample for BB and PR fresh tomatoes respectively. It should be emphasized that these results are in the range of values obtained by other scientists. Olajire at al. 2007 reported that lycopene content in tomato powder was 18.8.1 ± 0.9 mg/100 g [43]. Furthermore, in this research, the lycopene content was up to 10 times higher in dried tomato powder obtained from the Pink rock tomato variety, which also once again confirmed the fact that the lycopene content increases in the product compared to fresh tomato fruit. The highest value of lycopene was recorded in the BB sample that was dehydrated at 75 °C, and this value was 66.6 mg/100 g of the sample, which is also slightly more than 19 times higher value compared to fresh tomato fruit.

Results of antioxidant activity (FRAP, µmol Fe/100 g sample) of fresh tomato and tomato powder dehydrated at 50 °C and 75 °C

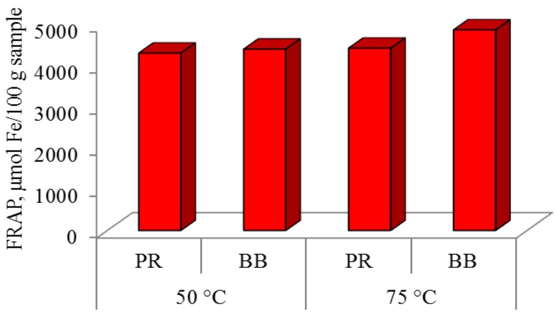

Figure 5. Antioxidant activity (FRAP, µmol Fe/100 g sample) of fresh tomato and tomato powder dehydrated at 50 °C and 75 °C

Tomatoes and tomato products are rich in food components that are antioxidant [44]. FRAP values for dehydrated tomato powder at a temperature of 50 °C were 4305 for sample PR, and 4401.25 μmol Fe/100 g sample for BB. By increasing the temperature to 75 °C, the FRAP values increased for sample PR 4425 and for sample BB 4868.75 μmol Fe/100 g sample.

Results of DPPH radical scavenging activity (IC50, mg/mL) of fresh tomato and tomato powder dehydrated at 50 °C and 75 °C

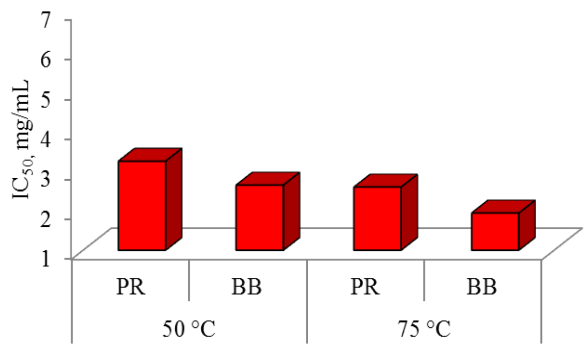

Figure 6. DPPH radical scavenging activity (IC_{50}, mg/mL) of fresh tomato and tomato powder dehydrated at 50 °C and 75 °C

Tomato varieties with a higher content of phenolic compounds show a higher antioxidant activity using the DPPH method, so it can be concluded that the antioxidant activity originates from the presence of phenolic compounds in the samples. As a result of the reaction with the antioxidant, the DPPH radical is converted into a non-radical form (removal of the free radical), which is detected by the decrease in absorbance, which is proportional to the activity of the antioxidant, and is expressed as a percentage of DPPH radical inhibition [45].

In this study, higher values of DPPH radical scavenging activity, expressed as IC50, mg/mL, were observed at lower dehydration temperatures, compared to samples that were dehydrated at higher temperatures.

IV. CONCLUSION

Dried tomatoes are a rich source of antioxidants: vitamin C, especially phenolic compounds and lycopene. This study determined the stability of antioxidant substances in tomato powder. The temperatures used in the experiment (50°C and 75°C) to obtain tomato powder had positive effects on the concentration of antioxidant substances. Of the values obtained for these substances, only the value of vitamin C is decreasing, due to the fact that vitamin C is thermolabile. However, a certain amount of vitamin C remains present in the powder, sufficient to satisfy the needs of the organism for this vitamin, which is taken with tomato powder. In contrast to vitamin C, the values obtained for phenols and lycopene are intensively increasing, which means that the applied temperatures are suitable for maintaining the high-quality chemical and nutritional composition of the obtained tomato powder.

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