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POTASSIUM CONTENT IN TOMATO AND TOMATO PRODUCTS

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Abstract

Tomato (Lycoperscion esculentum) is an annual vegetable crop of the Solanaceae family. It can be consumed as fresh food or processed in the form of pelee, concentrate, juice or ketchup. Potassium activates enzymes and regulates permeability of living membranes. The goal of this research was to determine the content of potassium in fresh tomatoes and tomato products. Tomato sampling was conducted on 3 sales places in Zagreb, including fresh grappolo tomatoes, fresh cherry tomatoes, ketchup, double concentrate (28-30 % DW) and organic tomato pelée. In order to determine the content of potassium, the grinded samples were digested with concentrated HNO_3 and $HClO_4$ in a microwave oven, potassium is determined by flamephotometer. The content of dry weight ranged from 4.2 to 30.4%. Statistically the highest potassium content was found in fresh grappolo tomatoes (7.5% K dry weight and 1783 mg K/100 g in fresh weight). Slightly lower potassium content was determined in fresh cherry tomatoes and peeled tomatoes, while in ketchup was statistically the lowest (1.97% K dry weight and 65 mg K/100 g in fresh weight).

Key words*: food processing, Lycoperscion esculentum, macroelement, mineral.*

INTRODUCTION

Tomato (*Lycoperscion esculentum*) as one of the most widespread vegetable crops, has a wide use as a food. It can be consumed both, fresh or processed. It is especially widespread and highly valued in Mediterranean cuisine. Potassium, as a part of tomato mineral composition, is the most abundant, followed by phosphorus, magnesium, calcium, sodium and iron. Tomato is richer in iron than fish, chicken, and milk (Matotan, 2008).

Tomato cultivars differ in the type of plant growth, production purpose, fruit shape and colour, early-maturing, and other morphological and biological properties (Lešić et al., 2004). For commercial production, hybrids are used which, in relation to cultivars, give higher yields and better genetic resistance to diseases and pests (Matotan, 2004; Parađiković, 2009).

As a part of canning and processing, tomatoes have taken an important place due to their organoleptic and culinary properties as well as nutritional value as a raw material. The value of tomato as a raw material for processing is assessed on the basis of mechanical (e.g. fruit firmness) and chemical composition, suitability of the fruit for processing, as well as the intensity of changes in the chemical composition of the product in relation to the incoming raw material. Tomatoes are most often processed as puree, concentrate, peeled tomatoes (concentrated whole fruits), tomato juice (as a beverage), sauces, and dehydrated products (Lovrić & Piližota, 1994).

In modern agriculture, which point out high yields, there are also high needs for potassium. In order to meet the potassium need, its uptake is necessary by mineral fertilizers (Butorac, 1999). The physiological role of potassium, as an essential biogenic element, was determined quite late because it is not a part of organic compounds. The basic functions of potassium are enzyme activation and regulation of living membrane permeability. As an electrolyte, it affects the regulation of turgor, burst work and the regulation of water content in the plant (Parađiković, 2009). Potassium deficiency, due to its complexity and important function in metabolism, has an impact on the overall growth and development of the plant. In the absence of potassium, the edges of well-developed older leaves turn yellow (edge chlorosis), later irreversibly brown (necrosis) especially when the weather is hot (Petek, 2016).

As for plants, biogenic elements are also essential for normal human growth and development. Thus, after calcium and phosphorus, potassium is the most abundant mineral in the human body. There are about 160 to 300 g of potassium in the adult organism, of which 98% is found in cells, and only 2% outside them (Lovrić, 2004). Thus, potassium is an essential constituent of the human body which can be supplied by consuming foods rich in potassium, such as tomatoes.

The aim of this study was to determine the potassium content in different samples of fresh and processed tomatoes according to the place of purchase.

MATERIALS AND METHODS

For purpose of this investigation on 5 Dec 2017 in city of Zagreb (Croatia) samples of fresh tomatoes and tomato products were collected: organic peeled tomato (under the trade name Bio-Tomaten gewurfelt aus biologischer Landwirschaft), double concentrate (28-30% dry weight), ketchup, fresh cherry tomatoes and fresh grappolo tomatoes. All samples were collected in triplicate in the SPAR retail chain at the locations Jordanovac, Kvaternikov trg (Kvatrić), and Britanski trg (Britanac). Each sample was cleaned and washed in distilled water in the case of fresh tomatoes, and the products were removed from the packaging and each sample was chopped and ground. The homogenised and mixed average samples were dried at 105 °C, after which they were ground and homogenized. Potassium was determined by flame photometer (Jenway, PFP-7) after digestion with concentrated nitric acid (HNO_3) and perchloric ($HClO_4$) in a microwave oven (Milestone, Ethos One) (AOAC, 2015). Dry weight (DW) was determined gravimetrically by drying to constant mass.

The samples, collected in triplicate, were analysed individually and the results showed as average values. Statistical data analysis followed the variance analysis model (ANOVA). The SAS System for Win program was used. ver 9.1 (SAS Institute Inc.), and Tukey's significance threshold test (SAS, 2002-2003) was used to test the results.

RESULTS AND DISCUSSIONS

Figure 1 shows the percentage of dry weight (DW) in fresh tomatoes and tomato products. The average dry weight (DW) content in the samples, regardless of the place of purchase, ranged from 4.22 to 30.45%. The highest percentage of dry weight was found in ketchup, while the lowest was found in fresh grappolo tomatoes.

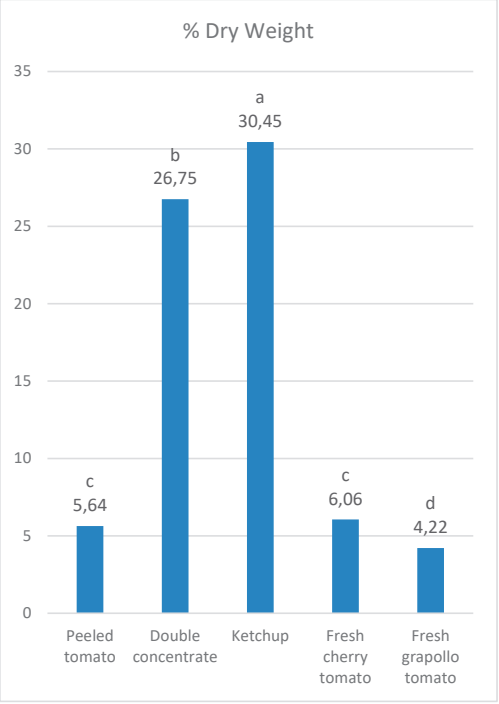

Figure 1. Average dry weight (DW) content (% DW) in fresh tomato and tomato products
Different letters represent significantly different values according to Tukey's test, $p \leq 0.05$. The non-letter values are not significantly different

Table 1 shows the percentage of dry weight in tomatoes and tomato products at different locations of the SPAR retail chain.

In fresh grappolo tomatoes was determined the lowest dry weight content, at the location SPAR Kvatrić 4.1% DM, followed by SPAR Britanac and SPAR Britanac (4.2 and 4.4% DW, respectively).

In fresh cherry tomato the dry weight content was 5.7% DW at the SPAR Jordanovac location, 6.0% DW at the SPAR Britanac

location, and 6.6% DW at the SPAR Kvatrić location.
Peeled tomatoes have similar dry weight content as fresh cherry tomatoes, at the location of SPAR Jordanovac and SPAR Britanac (5.3% DW). Finally, the highest percentage of dry weight in peeled tomatoes (6.3% DW) was determined at the SPAR Kvatrić location.
Double concentrate at the SPAR Jordanovac location obtained 25.6% DW, and at the SPAR Kvatrić and Britanac location it is very similar to the percentage of dry weight (27.5 and 27.2% DW, respectively).
Ketchup has the highest percentage of dry weight of all processed products, and the percentage of dry weight is almost the same in all samples: at the SPAR Britanac location 30.2% DW, at the SPAR Kvatrić location 30.4% DW and 30.7% DW SPAR Jordanovac.

Table 1. Dry weight (DW) content (% DW) in fresh tomato and tomato products according to sales locations

% dry weight	Sales locations		
	SPAR Jordanovac	SPAR Kvatrić	SPAR Britanac
Peeled tomato	5.3	6.3	5.3
Double concentrate	25.6	27.5	27.2
Ketchup	30.7	30.4	30.2
Fresh cherry tomato	5.7	6.6	6.0
Fresh grappolo tomato	4.4	4.1	4.2

The average tomatoes potassium content in dry weight, expressed as a percentage (% K DW), shows different values depending on whether the tomato is fresh or processed. Figure 2 shows the average values of potassium in dry weight (% K DW) ranging from 1.97 to 7.52% K DW. Quite similar average potassium content in dry weight was found in double concentrate, peeled tomatoes, fresh cherry tomatoes and fresh grappolo tomatoes ranging from 5.89 to 7.52% K DW, while the lowest potassium content was found in ketchup 1.97% K DW.

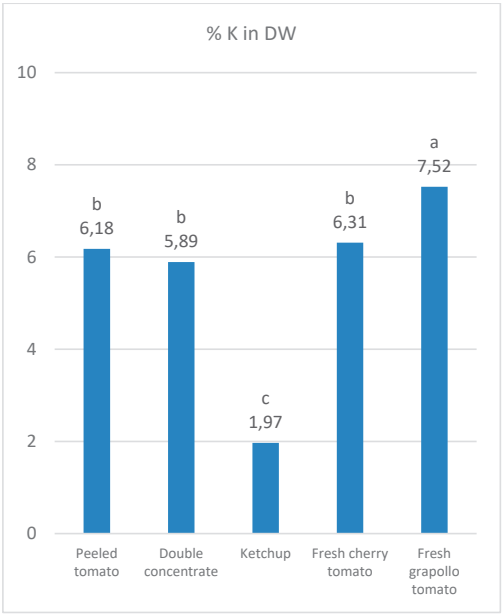

Figure 2. Average potassium content in dry weight (% K DW) in fresh tomato and tomato products Different letters represent significantly different values according to Tukey's test, $p \leq 0.05$. The non-letter values are not significantly different

Table 2. shows the percentage of potassium in the dry weight in fresh tomato and tomato products samples at different locations of the SPAR retail chain.
The highest potassium content was determined in fresh grappolo tomatoes at the location of SPAR Jordanovac 7.99% K DW, followed by SPAR Britanac 7.50% K DW, and SPAR Kvatrić 7.08% K DW.
The fresh cherry tomato in the SPAR store at the Britanac, Jordanovac, and Kvatrić locations has the following percentage of potassium in the dry weight: 6.72, 6.49, and 5.73% K DW, respectively. In peeled tomato potassium content was determined as follows: 6.75, 5.91 and 5.88% K DW in SPAR stores at the locations Jordanovac, Britanac, and Kvatrić, respectively. In double concentrate in SPAR stores at the locations Jordanovac, Britanac, Kvatrić has the following percentage of potassium in the dry weight: 6.47, 5.76 and 5.44% K DW, respectively.
The lowest potassium content in the dry weight was found in ketchup at the SPAR Britanac location of 1.91% K DW, while at the Kvatrić and Britanac locations the percentage was

slightly higher at 1.93 and 2.06% K DW, respectively (Table 2).

Table 2. Potassium content in dry weight (% K DW) in fresh tomato and tomato products according to sales locations

% K DW	Sales locations		
	SPAR Jordanovac	SPAR Kvatrić	SPAR Britanac
Peeled tomato	6.75	5.88	5.91
Double concentrate	6.47	5.44	5.76
Ketchup	2.06	1.93	1.91
Fresh cherry tomato	6.49	5.73	6.72
Fresh grappolo tomato	7.99	7.08	7.50

Figure 3 shows the average potassium content in fresh weight (mg K/100 g FW). The highest average potassium content was recorded in fresh grappolo tomatoes 1783 mg K/100 g FW, while the lowest average potassium content was recorded in ketchup 64.65 mg K/100 g FW.

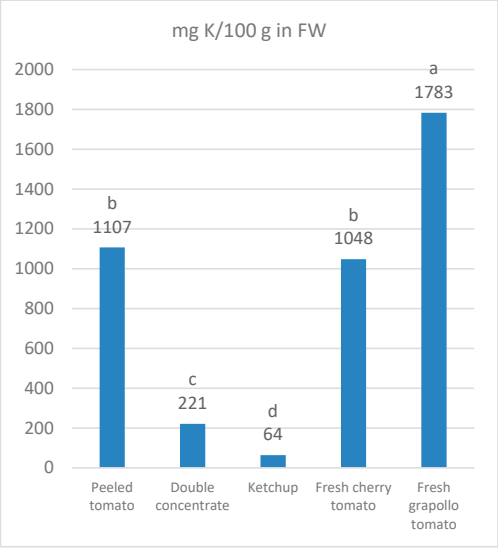

Figure 3. Average potassium content in fresh weight (mg K/100 g FW) in fresh tomato and tomato products Different letters represent significantly different values according to Tukey's test, p≤0.05. The non-letter values are not significantly different.

Table 3 shows the amount of potassium in fresh weight (mg/K 100 g FW) in tomato samples and tomato products at different locations of the SPAR retail chain.

The following potassium content in fresh weight was found in fresh grappolo tomatoes in the SPAR retail chain at the Jordanovac, Britanac and Kvatrić locations: 1829, 1725 and 1797 mg K/100 g FW, respectively.

Fresh cherry tomatoes are rich in potassium in fresh weight. At the SPAR Kvatrić location, 873 mg K/100 g FW was determined, followed by 1128 mg K/100 g FW at the SPAR Britanac location and the highest value of potassium content in fresh weight at the SPAR Jordanovac location of 1145 mg K/100 g FW.

In peeled tomatoes, the highest potassium content was determined at the SPAR Jordanovac location 1269 mg K/100 g FW, followed by the SPAR Britanac location 1124 mg K/100 g FW and 928 mg K/100 g FW SPAR Kvatrić.

In double concentrate at the SPAR Jordanovac location, the highest value of potassium was found (253 mg K/100 g FW), followed by SPAR Britanac 212 mg K/100 g FW and in SPAR Kvatric with a minimum value of 198 mg K/100 g FW.

The lowest potassium content in fresh weight was found in ketchup, at all three locations the values are very similar. At the SPAR Britanac location 64 mg K/100 g FW, followed by SPAR Kvatrić with 63 mg K/100 g FW and finally SPAR Jordanovac with 67 mg K/100 g FW.

Table 3. Potassium content in fresh weight (mg K/100 g FW) in fresh tomato and tomato products according to sales locations

mg K/100 g FW	Sales locations		
	SPAR Jordanovac	SPAR Kvatrić	SPAR Britanac
Peeled tomato	1269	928	1124
Double concentrate	253	198	212
Ketchup	67	64	63
Fresh cherry tomato	1145	873	1128
Fresh grappolo tomato	1829	1725	1797

According to various literature sources, the percentage of dry weight in fresh tomatoes (% DW) is as follows: Matotan (2004) 4-6% DW, Parađiković (2009) 3-6% DW and Lešić et al. (2004) 5-7% DW. In this study, the % DW of fresh grappolo tomatoes in the SPAR retail chain is 4.22%, while the % DW of fresh cherry tomatoes is 6.06%. Both types of fresh tomatoes are in agreement with the values of dry weight according to the literature data.

The dominant mineral in the composition of tomatoes is potassium (Matotan, 2008). Different authors reported different K fresh tomato fruit content. So, Assuncao et al. (2019) reported only 1.7-2.1 and Barker et al. (2019) 3.27-5.33% K DW, while in this study determined K content was higher (5.73-7.99% K DW).

Tomato, according to Lešić et al. (2004), contains the potassium content between 92 to 375 mg K/100 g FW. In this study, the determined average potassium value in fresh grappolo tomatoes is 178 and in fresh cherry tomatoes 1048 mg K/100 g FW. The average values of fresh grappolo and fresh cherry tomatoes deviate significantly from the values according to Lešić et al. (2004). The reasons can be many: climatic conditions, cultivation method (open field production, greenhouse production, hydroponics), fertilization, harvest time, hybrid, cultivation care, etc.

Peeled tomatoes obtain an average percentage of dry weight in the fresh sample of 5.64%. This product bears the Demeter mark, and is grown in accordance with Council Regulation (EC) 834/2007 produced without GMOs, and without the use of mineral fertilizers. Organic fertilization of tomatoes is most often based on compost and manure (Lončarić et al., 2015). In an experimental study, Pribetić et al. (2000) fertilized tomatoes with mineral fertilizers, compost and a combination of mineral fertilizers and compost. The results of the research showed a higher percentage of dry weight of tomatoes that was fertilized only with compost (7.6% DW) compared to the treatment without compost (4.8% DW). Tomatoes, intended to be processed, should have a higher percentage of dry weight.

The total dry weight of the finalised ketchup product should be between 25 to 35% (Lovrić and Piližota, 1994), in this study the average value of dry weight in ketchup is 30.43%. According to Vargek (2019) the dry weight value in ketchup can be variable depending on the manufacturer. The double concentrate in this study has an average dry weight value of 26.77% DW.

Tomato products in this study: peeled tomatoes, double concentrate and ketchup have different values of potassium in both dry weight and fresh weight. The average value of potassium in peeled tomatoes was 6.18% K DW, in double concentrate 5.89% K DW and in ketchup 1.97% K DW. The average value of potassium in the fresh sample in peeled tomatoes was 1107 mg K/100 g FW, in double concentrate 220 mg K/100 g FW and in ketchup 64 mg K/100 g FW.

The reason why peeled tomatoes contain so much more potassium compared to double concentrate and ketchup, probably is the production technology. Peeled tomatoes are made of peeled pieces of tomato in an infusion of their own juice, with the addition of 0.2% salt. Double concentrate is a product obtained by evaporation of juice produced by mashing crushed and heat-treated tomato fruits, with the addition of 2-3% salt. The production of ketchup consists of the preparation of concentrates by the usual process or by diluting the concentrate with a larger amount of dry weight, a series of spices including salt 2-3%, and the addition of additives (Lovrić and Piližota, 1994). Significant amounts of potassium from food are lost through food processing, i.e. heat treatment and canning. During the preparation of tomato products, salt (NaCl) is added, which can disturb the ratio of potassium and sodium in humans. Processed foods, in which salt is added, contains an average potassium to sodium ratio of 7:1, compared to unprocessed foods (web 1). Richer K fertilization resulted with higher K content in tomato (Sontag et al., 2018; Daoud et al., 2020; Rahim et al., 2020; De Luca et al., 2021). So, in order to improve nutritional quality of tomato and tomato processed products fertilization should be applied.

CONCLUSIONS

In the study are determined potassium content and dry weight content in fresh tomatoes and

tomato products. The dry weight content in the samples ranged from 4.22 to 30.45% DW. Determined potassium content in the dry weight was in range from 1.97 to 7.55% K DW and from 64 to 1783 mg K/100 g FW.

Statistically the highest potassium content in dry and fresh weight was found in fresh grappolo tomatoes. A slightly lower content was found in fresh cherry tomatoes and peeled tomatoes, while potassium content in double concentrate and ketchup was statistically the lowest.

Further research is needed with a precisely defined assortment, controlled cultivation that implies equal plantation care, equal fertilization, protection, irrigation, etc. in order to obtain more precise results.

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