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QUALITY CHARACTERIZATION AND PROCESSING OF SOME TOMATO VARIETIES

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Abstract

The aim of this work was to investigate the chemical characteristics of different varieties of tomatoes: Arizona, Aleksandar F1, Florida 47 F1, Rio Grande and Pik Ripe 748 Imp LSL F1. Chemical characterization of ripe tomato fruit was used in order to evaluate its potential in obtaining high yield of quality dehydrated product, and select the optimal tomato variety for Armenian solar drying. Dry matter content, content of total sugars and the ratio between sugars and titratable acids were examined as significant parameters for determination of high-quality tomato variety.

Also, analyses were carried out to determine the changes in pH, total soluble solids, protein and moisture content, both in ripe and dehydrated samples. Further comparison between the different types of samples was done. The results obtained were as follows: moisture 94.4-95.25 % and 12.0-17.65%; titratable acids 0.21-0.37% and 3.30-6.56%; pH 4.28-4.56 and 4.01-4.39; vitamin C 10.28-15.29 mg% and 26.92-38.60 mg%; proteins 0.55-1.17 % and 8.34-17.63%, for ripe and dry tomatoes respectively. TSS for processed tomatoes was 3.80-4.90 %, depending of the examined variety.

The best tomato varieties can be recommended for further solar drying. Armenian According to the obtained results, processing tomatoes into dehydrated products improves their nutritional quality mainly by concentration effect.

Key words: *Tomato varieties, solar drying, chemical characterization*.

1. Introduction

Tomato (*Lycopersicon esculentum*) is the most cultivated herbaceous plant in the Republic of Macedonia leading with 66% of vegetables production (Jankulovski *et.al*. [1]), but however, processing is not developed to its full potential. Tomato is cultivated in all parts of Macedonia due to its adaptability to a range of soil and climate. The best growing areas of tomato are south-east region in Macedonia, Ovče Pole and Povardarje with total production of 120000 - 140000 tons. In order to solve the problem of sufficient production, using different techniques, researchers and producers are trying to place ripe tomatoes on the market in their processed form. One possibility to achieve this is by solar dehydratation of selected assortment high quality fruit, which appeals to the consumers by the improved nutritional quality.

Tomato is widely consumed product in both forms, fresh and processed into sauce, pasta, puree, ketchup etc., due to its high nutritional value. It is a valuable source of food minerals, health promoting vitamins and disease fighting phytochemicals in particular lycopene (Reboul *et al*. [2]). Lycopene is carotenoide pigment, primarily responsible for the characteristic deep-red color of ripe tomato fruits and tomato products. The increasing number of clinical evidence indicates the role of lycopene, as a natural antioxidant, in providing protection against a broad range of epithelial cancers (Yang *et al*. [3]). In addition to carotenoids, tomato fruits contain considerable quantities of other bioactive compounds such as a- tocopherol and ascorbic acid, the most important antioxidant vitamins. According to Shanna *et al*. [4], antioxidant capacity of tomato products results mainly from these vitamins and carotenoids.

Due to the fact that tomato fruits are very consumed in Macedonia, our goal in this research was to determine the quality of selected ripening tomato varieties and to compare them with the corresponding dehydrated products. This is the first research of this type in Macedonia, and it should provide novel results for the nutritional quality of dehydrated products and also, offer valuable answers for further practical use and

application of Armenian solar drier (Bogdanovska [5]).

Consumers' acceptance of tomato-based products is in correlation with the quality characteristics such as color and texture. Textural properties of tomato fruit play an important role in the overall quality, both in fresh market and processed tomatoes, and can be associated with parameters like total acids (TA), total soluble solids (TSS) and their ratio (TSS/TA) (Hossai *et al*. [6]).

This study has been designed to investigate the quality of ripe and dehydrated tomato fruits analyzing their physicochemical parameters: dry matter content, total soluble solids (TSS), protein and reducing sugars content, changes in pH, vitamin C and titrable acids. Furthermore, the aim of this work is to compare different cultivars and to determine the relationship between total soluble solids and total acidity, as main parameter for determining fresh fruit quality.

2. Materials and Methods

Five different tomato varieties grown in greenhouses in Ovče Pole, Republic of Macedonia, were used in this study (see Table 1):

Table 1. Pomological characteristics of tomato fruits

Variety	Shape	Average height (mm)	Average width (mm)	Average weight (g)
Pik Ripe 748 Imp LSL F1	spherical	64.06	86.77	263.02
Alexandar F1	spherical	65.12	82.04	221.65
Arizona	spherical	68.17	71.24	174.30
Rio Grande	oval	70.14	51.87	93.76
Florida 47 F1	spherical	73.10	93.15	316.63

The experiment was set up according to the randomized block design, comparing 50 plants, each in triplicate. Fruits were picked up at full technological maturity (full red color) at the beginning of September 2007 and 2008, respectively. A mass of 10 kg of fruits was taken randomly for each replication. Fruit samples were analyzed immediately after harvesting.

The ripe fruits of different tomato varieties were selected, calibrated and washed with microbiological and chemical safe drinking water. Afterwards, tomatoes were strained, cut to small pieces and placed on wooden hurdle gate with metal sieving grids (10 kg fruits/1 m^2 surface hurdle-gate) of Armenian solar dryer with 100 kg capacity. Tomato fruits were dried for 2 days (48 hours).

The fruits were pulverized in a homogenizer (Ika Labortechnik T25) and prepared for further analysis. Three replicates were used per analysis. The following quality parameters of fresh tomato fruits were determined: dry matter (total and soluble), total acids (TA), pH value, reducing sugars, vitamin C, total soluble solids/total acids ratio (TSS/TA) and proteins.

Total dry matter (DM) was determined by drying homogenized tomatoes at 105°C until constant mass (AOAC International [7]). Total soluble solids (TSS), were measured using refractometer. Total acidity (TA) was measured according to the AOAC method [7] and expressed in % of citric acid. The acidity (pH value) was measured with a pH meter (Hanna Instruments PH-301). Ascorbic acid (AA) was determined by the 2,6-dichloroindophenol using Tilman's titrimetric method according to the AOAC [8]. Protein content was determined by Kjeldahl method (AOAC International [7]).

Reducing sugars were determined by Luff-Schoorl method (AOAC International [7]), modified for analysis of ripe and dehydrated tomatoes with low content of sugars. The advantage over other volumetric procedures is non-interference with other types of molecules that can act as reducing agents. Namely, under slightly alkaline conditions (pH 9.3) oxidation occurred only with aldoses and ketoses, not with aldehydes present in the matrix.

Extraction was done from 10 g of fresh and dehydrated fruits using 100 mL of H_2O. For elimination of ballast matter, Carrez clarification was done by adding 5 ml of Carrez I and 5 mL of Carrez II to 50 mL of obtained extract for fresh fruit and 25 mL for dried form of the sample [9]. The content was then mixed, pipetted into a 250-mL volumetric flask, and filled to the mark with distilled water (dH_2O), then mixed again and filtered. After that, 25 mL of Luff-Schoorl solution and 25 mL of obtained filtrate were added into an Erlenmeyer flask and heated for 2 min on direct flame followed by boiling on reverse cooler for additional 10 min. To a cooled content, 9 mL of potassium iodide solution and 25 mL of 25% H_2SO_4 were added. The excess of copper (II) was determined iodometrically. The obtained mixture was titrated with $Na_2S_2O_3$ (0.1 mol/dm^3) until yellow color appeared, then a few drops of starch solution were added and titration continued until the blue color disappeared. Procedure for the control sample was conducted in parallel.

Unreduced sugars were first transformed by acid hydrolysis into reduced monosaccharide's, by Luff-Schoorl method (AOAC International [7]). The sucrose mass fraction was determined from the difference between total and reduced sugars.

3. Results and Discussion

Cultivar quality is defined by different parameters, which united give an integral picture of selected fruit. The hypothesis underlying this research was that

dehydrated tomato cultivars have improved nutritional quality.

The following quality parameters were determined in this investigation: total dry matter (DM), total acids (TA), total soluble solids (TSS), TSS/TA ratio, pH value, reducing sugars, vitamin C and protein content. These parameters were investigated in order to monitor fruit quality of ripe tomato varieties. Obtained parameters of the basic chemical composition of fresh fruits are given in Table 2.

Cultivar Florida 47 F1 has shown the highest statistically significant content of dry matter and total soluble solids. This Dutch tomato hybrid is widely grown in Macedonia because of its production technology, it is not very demanding and it is very well accepted for fresh consummation. Cultivars Alexandar, Rio Grande and Pik Ripe had slightly lower values of dry matter and total soluble solids.

Table 2. Chemical composition of ripe tomato cultivars

Hybrid variety	year	DM (%)	TA (%)	TSS (%)	TSS/ TA	pH	ω reducing sugars (%)	Vita-min C (mg %)	Protein content (%)
Florida	2007	5.45	0.35	4.83	13.80	4.28	3.05	23.96	1.10
	2008	5.60	0.37	4.90	13.24	4.30	3.11	24.11	1.13
Alexa-ndar	2007	5.35	0.30	4.75	15.83	4.30	2.66	21.65	0.90
	2008	5.40	0.33	4.80	14.55	4.32	2.71	21.76	0.95
Rio Grande	2007	5.10	0.23	4.65	20.22	4.45	2.04	25.10	0.55
	2008	5.00	0.27	4.60	17.04	4.48	2.09	25.29	0.60
Pik Ripe	2007	4.95	0.21	4.75	22.62	4.50	2.49	20.34	1.15
	2008	5.00	0.24	4.80	20.00	4.56	2.56	20.58	1.17
Arizona	2007	4.90	0.26	3.95	15.19	4.35	1.70	20.28	1.14
	2008	4.75	0.28	3.80	13.57	4.39	1.76	20.58	1.16

Total soluble solids (TSS) of tomatoes are a measure of all the soluble solids that are dissolved in the fruits. This includes sugars, salts, acids, vitamins etc. In our research, total soluble solids ranged from 3.80 to 4.90% and the obtained data are in accordance with previous studies. According to Tudžarov [10], the quantity of total soluble solids in the investigated cultivars ranged from 3.46 to 4.18%, while Hossai *et al*. [6] reported values for total soluble solids from 4.79 to 6.02%, depending on the cultivar.

The relationship between total soluble solids and total acidity is very important in determining tomato quality for further processing, because it provides information on the balance of sugars and acids in the fruit. The range of titrable acidity content varied from 0.21 to 0.37%. Total acidity values for cultivars Rio Grande and Pik Ripe were somewhat lower, which reflects in their higher TSS/TA values compared to cultivar Florida. TSS/TA values between other investigated varieties Florida, Alexandar and Arizona were very similar. The differences are evident among different cultivars.

The acidity value (pH) showed statistically significant variation among the varieties and the results are presented in the Table 2.

As well as being an important source of energy and dietary fiber, carbohydrates also contribute to physicochemical properties of foods such as the sweetness, appearance, stability and textural characteristics. Reducing sugar content showed statistically significant variation among the varieties and followed the same tendency as DM and TSS values. Among all analyzed varieties, Florida has the highest reducing sugar content, while Arizona has the lowest reducing sugar content. The range of reducing sugar content varied from 1.70% to 3.11%. Similar trend of reducing sugar content in fresh tomatoes has been reported (Niketić-Aleksić [11]). The absence of sucrose amount is explained by similar values for reducing sugars obtained before and after inversion. In respect to the quality parameter studied, fresh fruits of Florida cultivar at full ripe appeared to be the best for immediate consumption.

Vitamin C ranged from 20.28 mg per 100 g of fresh mass in cultivar Arizona to 25.29 mg per 100 g of fresh mass in cultivar Rio Grande. These data are in correspondence with the work of Jankulovski *et al*. [1]. In their research on six different tomato cultivars, obtained values ranging from 21.31 to 26.98 mg per 100 g of fresh mass. Hossai *et al*. [6] reported values of vitamin C from 17.32 to 26.59 mg per 100 g fresh mass, depending on the tomato cultivar.

Considering all the varieties, Pik Ripe, Arizona and Florida have the highest and similar protein content. The range of protein content varied from 0.55 to 1.17% and the obtained data are in accordance with the investigations of Vračar [12].

The main effects of cultivar on quality characteristics of dehydrated tomatoes are given in Table 3.

Table 3. Chemical composition of dehydrated tomato cultivars

Hybrid variety	year	DM (%)	TA (%)	pH	ω reducing sugars (%)	Vitamin C (mg %)	Protein content (%)
Florida	2007	82.35	4.15	4.01	11.23	38.00	15.64
	2008	82.50	4.48	4.05	11.30	38.22	15.82
Alexandar	2007	83.04	6.46	4.08	8.87	46.25	16.51
	2008	83.10	6.56	4.13	8.93	46.46	16.82
Rio Grande	2007	88.00	3.30	4.32	10.49	34.48	8.34
	2008	87.90	3.46	4.36	10.55	34.70	8.53
Pik Ripe	2007	84.05	4.65	4.34	7.85	36.92	15.05
	2008	84.12	4.80	4.39	7.93	37.05	15.27
Arizona	2007	83.15	5.56	4.11	7.00	48.60	17.50
	2008	83.00	5.76	4.15	7.06	48.81	17.63

Comparison between the dry matter values of fresh tomatoes (Table 2) and solar dried fruits (Table 3) shown that 14.75 kg to 17.5 kg of fresh fruits are required to get 1 kg dehydrated tomatoes, depending of the tomato variety and final moisture content. The moisture content determined on obtained samples of dehydrated Rio Grande and Pik Ripe cultivars have lower values, when solar drying was achieved in same time under the same experimental conditions in Armenian drier.

From obtained results for pH given in Table 2 and Table 3, it is evident that dehydrated tomatoes had a decreased pH ($P<0.05$) compared to the ripe sample. This can be attributed to the fact that processing of tomatoes with Armenian solar drier increases total acids. An approximation of the products total acidity is the titrable acidity. On the other hand, it also indicates the level of organic acids that are present in a product. The predominant acid in both, ripe and dehydrated tomato forms is a citric acid.

The dehydrated tomato varieties had higher amount of vitamin C than ripe samples which, perhaps, is due to concentration effect. The vitamin C content in the analyzed dried tomatoes depends on the variety and is in the range of 34.5 to 48.8 mg per 100 g dry matter. It can be concluded that there is a possibility for vitamin C oxidation during the process of solar drying on temperatures above 70 °C. Namely, vitamin C is water soluble vitamin and is considered to be susceptible to decomposition during processing. It is oxidized in the presence of air, catalyzed by ascorbic acid oxidize to dehydroascorbic acid (DHAA), which has no vitamin C activity (Shi and Le Maguer [13]). The results indicate that the present amount of moisture influenced the amount of vitamin C during solar drying. The decrease of vitamin C as a result of temperature of Armenian solar drying of about 70°C can be attributed partly to the significant loss of water together with the destruction of ascorbic to dehydroascorbic acid.

Considering all varieties, dehydrated samples of Florida and Rio Grande have the highest reducing sugar content compared to the others.

Based on all of the above-mentioned results, processing tomatoes into dehydrated products improves their nutritional quality and protein content mainly by concentration effect (i.e. removal of water).

4. Conclusions

- In this study, physicochemical characteristics of five different varieties of tomatoes: Arizona, Alexandar F1, Florida 47 F1, Rio Grande and Pik Ripe 748 Imp LSL F1 were investigated using known and modified facile and inexpensive methods.
- Chemical characterization of ripe tomato fruit was done by determining dry matter content, total soluble solids (TSS), protein and reducing sugars content, changes in pH, vitamin C and titrable acids in order to evaluate its potential in obtaining high yield of quality processed product. The conducted research was shown that Rio Grande and Pik Ripe varieties are the best quality cultivars and can be recommended for further processing.
- Tomatoes are processed into sauce, paste, puree, ketchup, but also can be conserved by solar drying which is an eco-friendly source of energy. According to some scientific research, Republic of Macedonia is a country with high insolation (average of 2200 sun hours per year), and this possibility for exploitation of solar energy was used for processing dehydrated tomatoes by Armenian solar dryer. Armenian solar dryer is convenient because it contributes to fruit and vegetable conservation nearest to the place of production without using other sources of energy.
- The obtained results clearly indicate that the investigated dry tomatoes compared to the corresponding ripe cultivars have a satisfying quality and nutritional value. Furthermore, processing tomatoes into dehydrated products has improved their nutritional quality mainly by concentration effect.

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