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MICRO TOXINS AND ORGANOLEPTIC PROPERTIES OF PROCESSED TOMATO PASTE USING ULTRASOUND, DETERMINATION OF ULTRASOUND SPECIFICATIONS

Danelia G.[1*], Andriadze G.[2] and Gelovani N.[3]

*[1]Technical University of Georgia, Professor of the Department of Chemical and Biological Engineering, Technical University of Georgia 0175.

[2]Doctoral Student of the Chemical and Biological Engineering Program of the Technical University of Georgia, 0175. LTD Ovamedi Medical Company, Georgia.

[3]Technical University of Georgia, Professor of the Department of Pharmacy, Head of the Biocomplexes Reception and Research Center, Georgia, 0175.

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***Corresponding Author**
Danelia G.
Technical University of Georgia, Professor of the Department of Chemical and Biological Engineering, Technical University of Georgia 0175.

ABSTRACT

The latest modern science considers vegetables as a vital product, which is an important part of any country's agricultural policy. Although their specific share is quite diverse, vegetable has an important place in Georgia. We are focused on the most popular vegetable - tomato, which is used by the public throughout the year both raw and canned. Attention should be paid to technical ripening and canning processes of tomato, where sanitary-hygienic conditions, must be followed which are developed by regulations and have certain requirements. The aim the research is to analyze selected innovative non-thermal processing technologies in tomato paste, to characterize their effectiveness in ensuring the quality and shelf life of tomato paste, aspects of technology sustainability and new trends. Using advanced technology, biologically valuable and ecologically pure tomato paste without emulsifiers was developed. Two technological methods were use to process tomato paste. By the first method tomato paste was processed using heating the tomato puree at 85-100°C and evaporate water to obtain tomato paste with about 25 %, brix. Canning process was at 100-104°C, 15min. By another method tomato paste was processed at 46°C, using 40kHz, 60w ultrasound. Processed product was canned at 46°C in sterile cans. No additional sterilization

performed. The chemical and microbial analyzes were performed. No Vitamin C reduction and aerobic on anaerobic microbes found in tomato paste processed using ultrasound. Vitamin C was reduced in the product obtained by industrial method using heating at 85-100°C. The processing of the product using innovative technology consumed less energy by 2.5 times with comparing the industrial method.

KEYWORDS: tomato, tomato paste, ultrasound, vitamin C, sterilization.

Despite of the fact that tomato plant (Solanum lycopersicum) is not belonging to the native species in Georgia and the origin of which is South America, the best tomato species are cultivated on appropriate altitudes (the best is 200-800m from the sea level) of Iveria and Kolkheti dales, however their subspecies undergo mutation changes together with the genetical selection management. Tomato species are mostly widespread on yellow, light brown, brown and black soils, those soils have impact on biochemical and mineral composition of tomato fruits. So, the colloid system together with the related abiotic factors of soil are important – in particular: lighting, which has impact on quality of photosynthesis, irrigation as needed, chemicalization (technogenesis), usage of so-called salt producing oxides and organics, pH level of soil (it should be noted that soil acidity was checked with a portable pH meter), and the amount of rainfall in the mentioned locations.

Despite of belonging of tomato plant to the family of Nightshades, the subspecies are different by anatomy and morphology e.g., every vegetative organ of parenchymal and prosenchyma leaf cells. They form organoleptically different properties (color, smell, taste, aroma, consistency and structure) for each landscape.

The purpose of the work is to research raw materials, soils and tomato paste processed using the new innovative technology with ultrasound. Today international market and competitiveness is wide available, which also gives real opportunity for falsification, which has a negative impact on society, and acute chronic diseases of human including children.

There are some native species widespread in Georgia, including “Choportula”, “Samepho”, “Sagviano”. Those species have unique properties of taste when they are technical maturity. It should be noted that in addition, geographical location of the country is also very important.

MATERIALS AND METHODS

During the research Carbonates in soil samples were determined by the Scheibler method, mobile phosphorus - by the Machigin method, exchangeable potassium - by the Kirsanov method, hydrolytic nitrogen - by the Tyurin-Kononov method. Nitrates in tomato research samples were determined by the Griess method, heavy metals - by the atomic-adsorption method, ash content - by the difference method after high-temperature exposure, simple sugars - by a field refractometer, ascorbic acid - by special rapid test sticks, hygroscopic water - by high-temperature drying method, raw cellulose – by the Henneberg-Stohmann method, pH - with a portable measuring device. Determination of microorganisms in tomato paste was carried out by the ISO 4833-1:2013/2015 method. All materials in contact with the study product are made of 304 grade stainless steel.

RESULTS AND DISCUSSION

Study of mineral and biochemical composition of tomato fruits by months after May, when consuming of tomato fruits are most intensive, was very interesting. The results showed several changes in tomato fruits until the maturity period. The results are shown in the table 1 and the figures 1, 2, 3, 4.

Table 1: Mineral and biochemical composition of raw tomatoes.

Bar code	Localization	Tomato species	Free water by months, % Standardization ranges 96-85%					Ash, %	Crude Cellulose, %	Ascorbic acid, mg %	Fructose, %	Titratable acidity, %	Nitrates by months, mg/kg (Maximum Permissible Concentration (mpc) 150 mg/kg)					Pb mg/kg (mpc 0.5 mg/kg)	As mg/kg (mpc 0.2 mg/kg)	Hg mg/kg (mpc 0.02 mg/kg)
			VI	VII	VIII	IX	X						VI	VII	VIII	IX	X			
484	Marneuli, North place	Choportula	96	95	93	93	92	3.5	0.8	10	5.0	0.4	130	120	115	105	75	0.001	0.007	0.004
		Samepho	-	95	95	94	-	2.5	0.8	10	5.3	0.5	120	119	100	95	78	0.002	0.007	0.003
		Sagviano	-	-	-	-	96	1.3	1.1	10	4.3	0.3	-	-	-	-	105	0.001	0.005	0.002
	Gori District	Choportula	97	95	94	93	91	1.3	0.8	10	4.5	0.3	180	175	145	99	77	0.008	0.006	0.009
		Samepho	-	94	93	93	-	2.0	0.9	10	5.0	0.5	128	120	117	114	101	0.1	0.007	0.004
		Sagviano	-	-	-	-	94	1.5	1.0	10	5.0	0.3	-	-	-	-	98	0.005	0.008	0.002

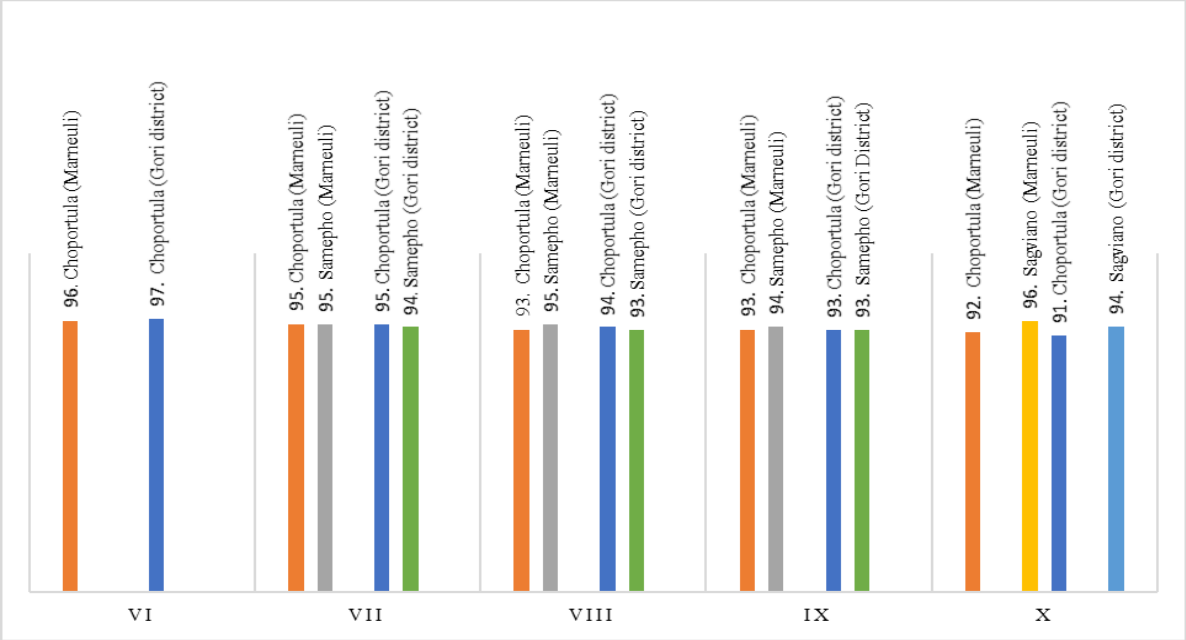

Figure 1: Raw tomato free water contents (%) in June-October periods.

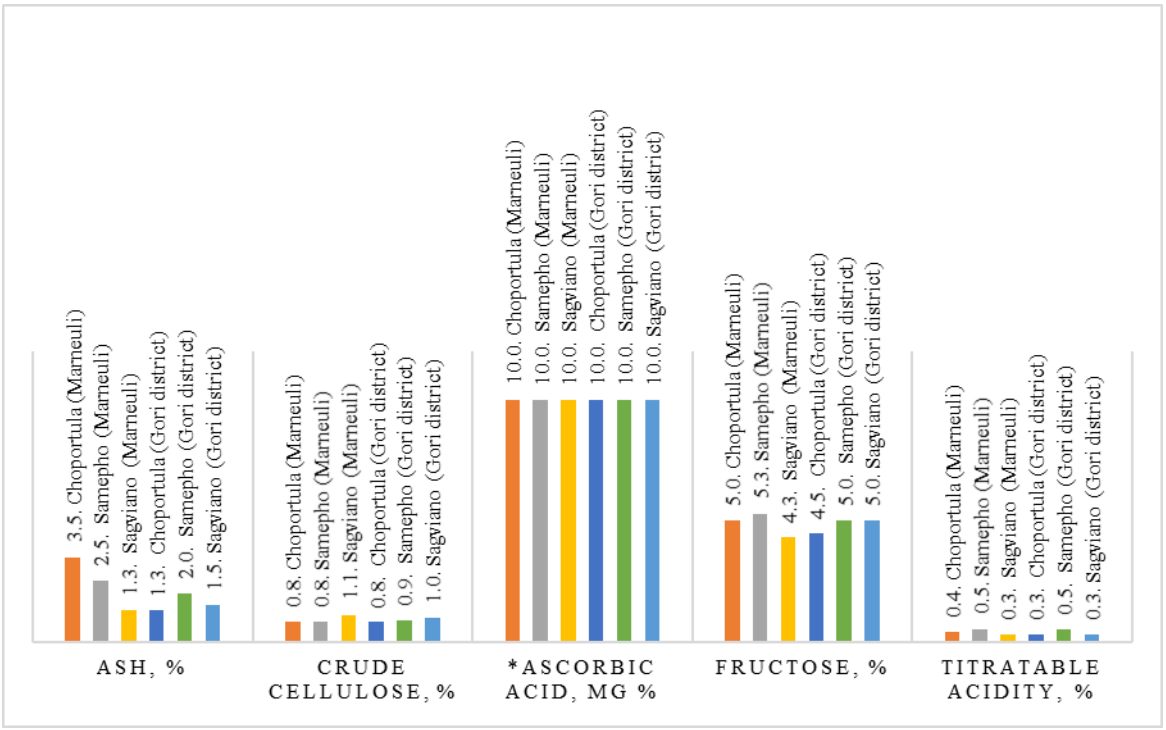

Figure 2: Biochemical composition of raw tomatoes. *- Vitamin C is determined by quick test strips, so rounded values are given.

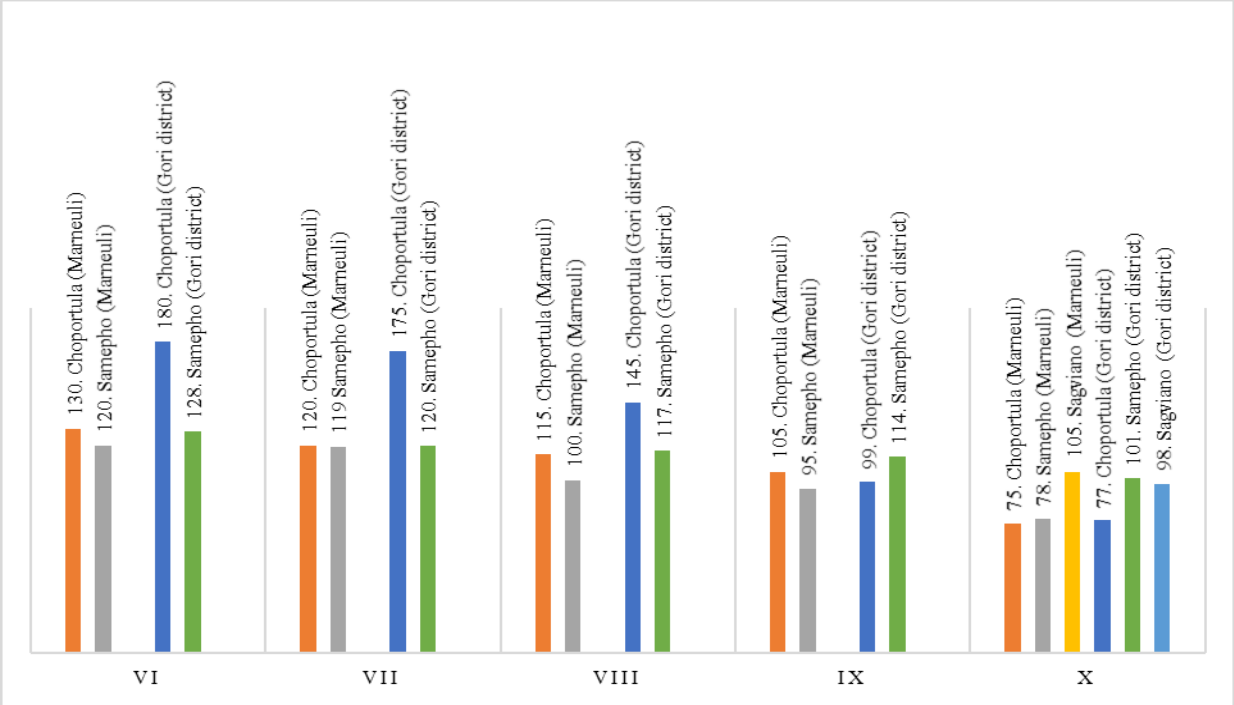

Figure 3. Raw tomatoes nitrates contents (mg/kg) in June-October periods.

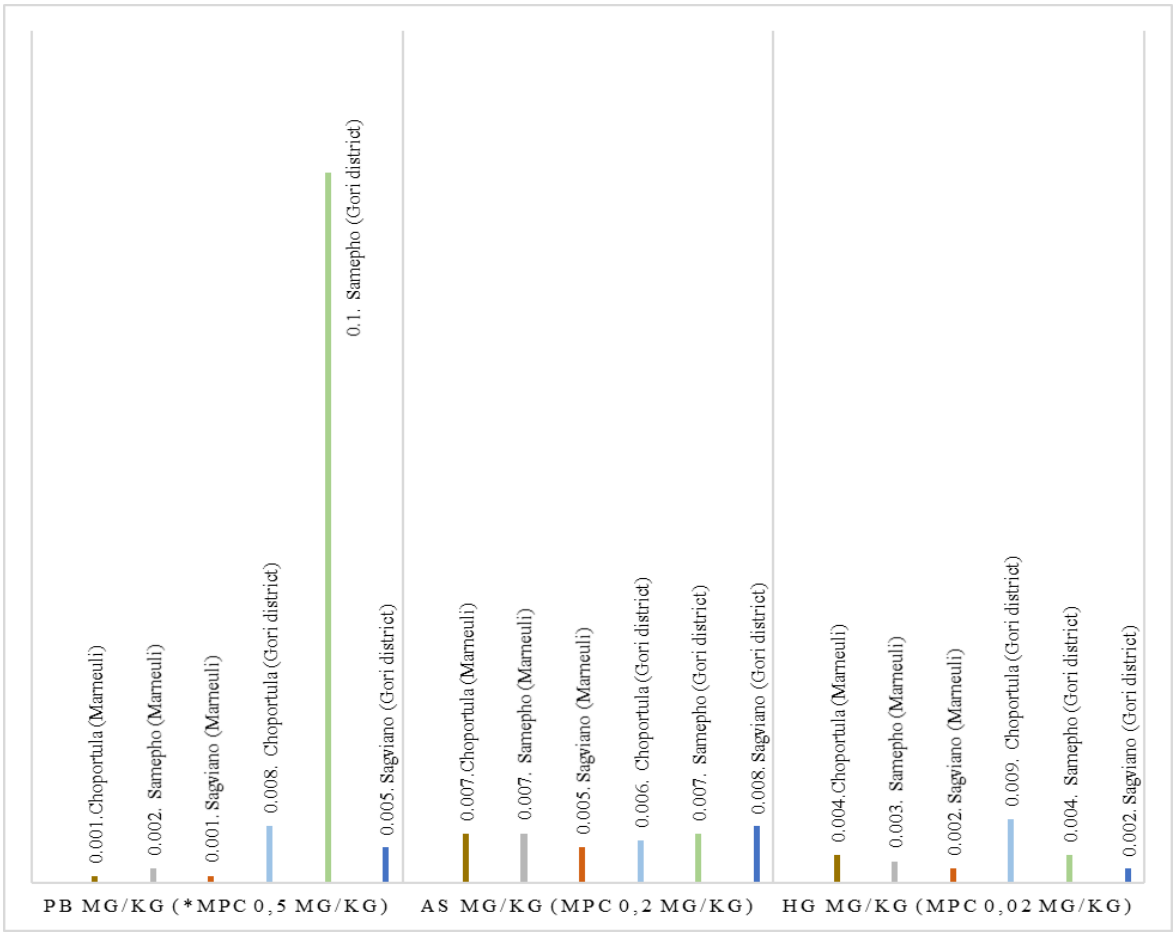

Figure 4. Content of heavy metals in raw tomatoes (mg/kg).

The samples of raw tomatoes (in condition of technical maturity) were taken in different locations, in particular those were Gori district (Sveneti, Ateni, Khidistavi) and the north side of Marneuli. Nowadays there is low chemicalization level in Georgia, mainly milled manure is used as the fertilizer (30 kg per 1 hectare). The current chemical composition of the soils are given in table 2 and figures 5 and 6.

Table 2: Composition of soils on harvested tomato locations.

Localization	Soil type	Sampling depth, cm	pH	Hummus, %	Carbonation, %	Hydrolitic nitrogen, mg %	Moving phosphorus, %	Exchangeable potassium, %
Marneuli black soils	Pasture	0-20	7.0	1.8	4.8	7.2	0.88	11.0
		20-40	7.3	1.7	4.9	0.5	0.77	9.8
	Fertilized	0-20	7.0	1.8	4.8	7.0	3.6	18.0
		20-40	7.0	1.7	4.9	6.5	3.4	16.0
Accumulation zone of brown soils (Gori districts: Sveneti, Ateni, Khidistavi)	Pasture	0-20	7.1	2.1	5.6	5.6	1.0	15.5
		20-40	7.4	2.1	1.7	4.7	0.8	15.3
	Fertilized	0-20	7.7	2.1	11.1	4.6	8.6	12.4
		20-40	8.1	2.1	12.8	4.3	8.4	11.2

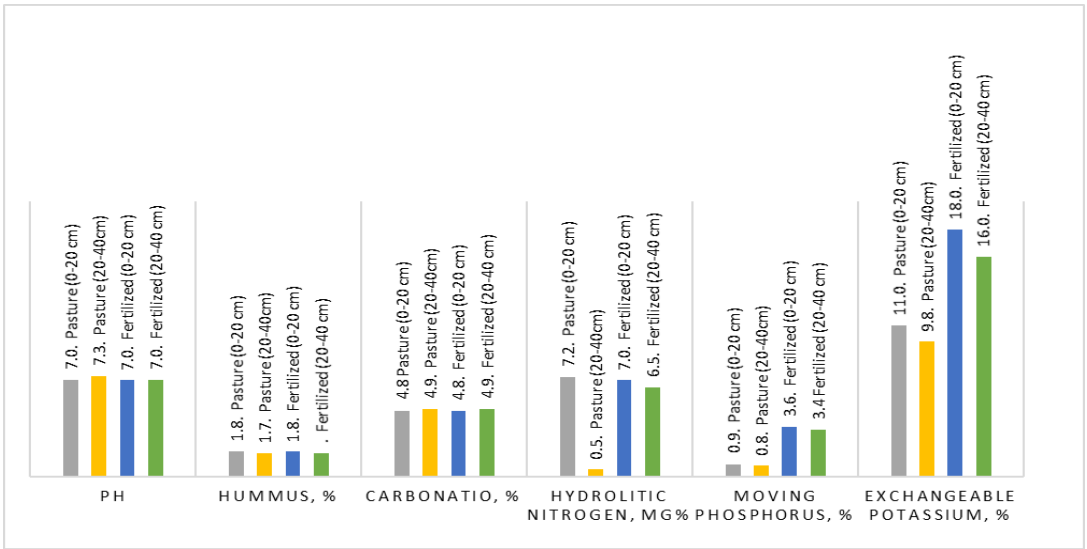

Figure 5: Composition of black type soil in the depth of 0-20cm and 20-40cm in Marneuli.

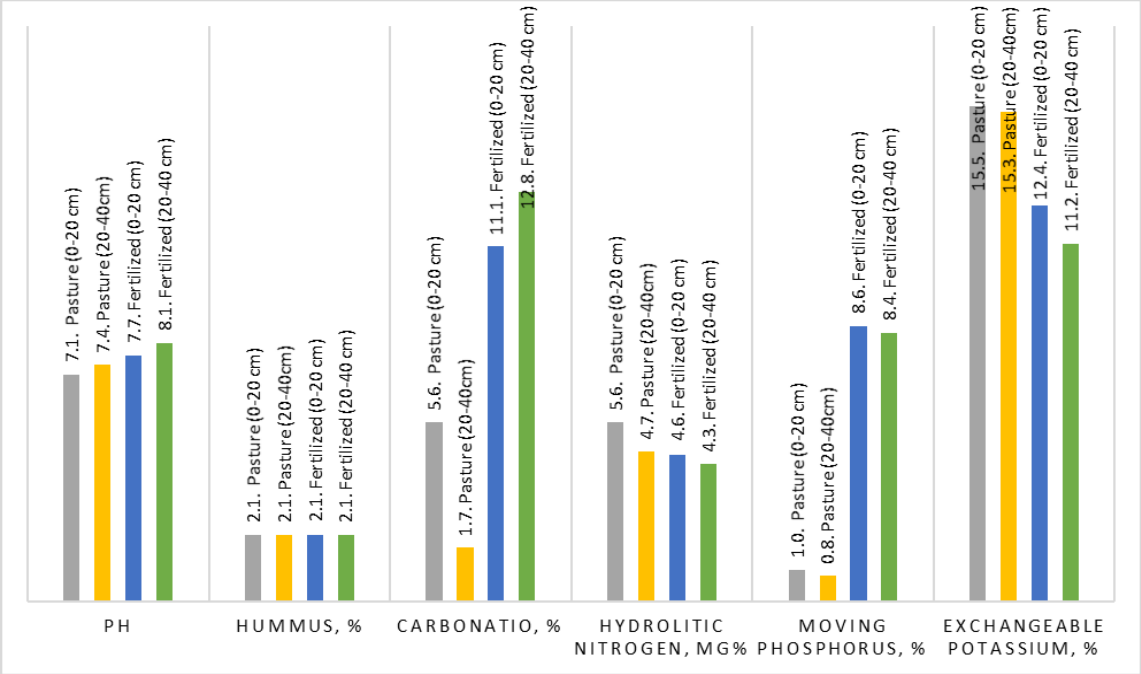

Figure 6: Composition of the accumulation zone of brown type soil in the depth of 0-20cm and 20-40cm in Gori district (Sveneti, Ateni, Khidistavi).

Analyzes of both plants and soils were carried out using quantitative validated methods: all indicators for the colloidal system of soils are indicated, but it should be noted here that salt-forming compounds, including ammonium and urea salts, were replaced by organic matter, since they are rich in crenic, apocretic and fulmic acids. They found expression in relation to the quality of post-harvest products. As for entomological and phytopathological diseases, they were not encountered, although tomato species are prone to mycotic diseases. Therefore, the plants were treated 4 times with a 1% $CuSO_4$ solution. On the second day after harvesting, the production of tomato paste was carried out using an innovative technological regime. The organoleptic properties of tomato raw materials were previously studied. Despite the fact that the organoleptic are identical and not subjective, what is important here is their appearance, which fully corresponds to the quality appearance, and the set of characteristics of the tomato (mineral and biochemical part) corresponds not to the standard, but to the maximum permissible concentrations applied to the species. Color tone, smell, taste, aroma, structure and consistency have been studied organoleptically, which leaves a positive impression for the preparation of tomato paste.[1, 2, 3] A distinctive feature of the model is the equipment and technology with which the produced tomato paste does not contain any additives (emulsifiers, dyes) and is complete. It should be noted that today sterilization of fruit juices and milk by ultrasound is widely used.[4, 5, 6]

All materials in contact with the product under study are made of stainless steel grade 304. For the production of tomato paste, “Sagviano” tomato was used in October, “Samepho” and “Choportula” in June.

Tomato paste was processed in model apparatus with both, using the classical method and using the innovative technology we studied - using ultrasound. Ultrasound frequency 40 kHz, power 60 W. See Figure 7.

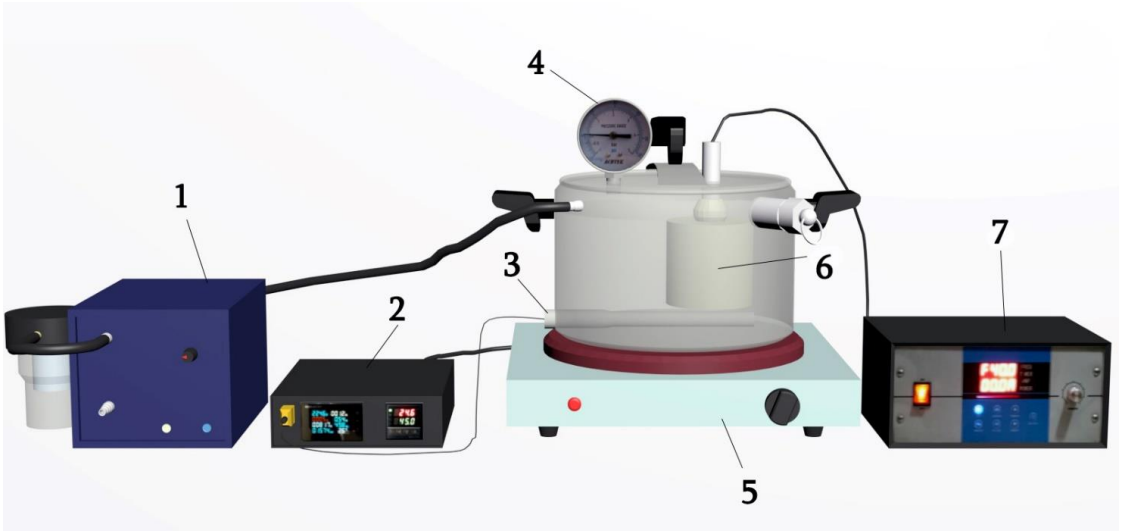

Figure 7: Tomato juice concentrator equipped with an ultrasound generator.
1. vacuum pump; 2. Controller of temperature power of the oven; 3. Termocouple; 4. vacuum-manometer; 5. Controlled electric oven; 6. Ultrasound generator; 7 Control unit of the ultrasound generator.

In order to increase the amount of ascorbic acid in tomato paste prepared under different conditions, red sweet pepper (Capsicum annuum) was added to the initial raw material in amount to get acceptable daily requirement dosage of vitamin C for adults in 100 grams of tomato paste.[7, 8]

The operating time of the ultrasonic generator is partially dependent on the ambient temperature; the automatic controller of the ultrasonic generator turns it on and off to maintain the programmed temperature required for the tomato paste preparation process. Since the ultrasonic generator itself generates heat during operation, it is necessary to synchronize its operation with the heating plate so that the temperature does not go beyond the limits. In the ambient temperature range of 23°C...27°C, the ultrasonic generator of the innovative device operates 90-92% of the total time.

Content of vitamin C was determined in all samples of freshly prepared tomato paste. The analyzes showed that ascorbic acid was not reduced in samples using ultrasound, whereas the concentration of ascorbic acid was reduced in tomato paste prepared by thermal evaporation. The sonicated tomato paste appeared bright and healthy, indicating that it retained other nutrients in addition to ascorbic acid that contribute to quality and taste.[9, 10] The above indicates the advantage of using ultrasound, since ultrasound sterilizes at a temperature of 46°C, and there is no need to heat it to high temperature, which ensures the preservation of vitamin C and other beneficial substances in tomato paste, which results in a live and healthy product.

A year after receiving experimental samples of tomato paste, microbiological analyzes were carried out (content of mesophilic aerobic and facultative anaerobic microorganisms in 1 g of product according to ISO 4833-1:2013/2015) of all samples. There were no visual signs of gas accumulation or mold in any of the samples. Anaerobic and aerobic microorganisms were also not found in any of the samples, which indicates the high quality of the tomato paste made using innovative technology, its ecological purity and high nutritional value. See Table 3.

During the processing of tomato paste citric acid, sweet pepper and salt were added in small amounts, usage of the final product for chronic diseases of the gastrointestinal tract and in baby food should be taken in account. Shelf life is more than 2 years at temperature ranges of 4-5 degrees. At the same time, the content of mesophilic aerobic and facultative anaerobic microorganisms in 1 g of product was studied by an official laboratory, no microorganisms were found in it.

In the case of real homogenization and the use of ultrasound, it is important that there were no changes in the degree of dissociation of low molecular weight electrolytes. Which is a positive development for maintaining the consistency and structure of products.

Table 3: The comparison of main qualitative characteristics of tomato pastes and their raw materials, obtained by heating and ultrasound, per 1000 grams of raw materials.

Product	Ratio: Tomato : pepper	Free water, %	Vitamin C, mg %	Ranges of pH of tomato paste	Processing time, min.	Consumed energy, kW/h	Processing temperature, °C	Refraction index on Brix scale, %
Tomato puree (June)	21:1	96	10	3,8 - 3,6	20	0.002	23.1	4
Sweet pepper puree (June)		92	250		5	0	23.2	8
Mixture of tomato and sweet pepper purees (June)		95.8	40		10	0.001	23.2	4,9
Tomato paste, 40kHz (June)		74	235		470	0.288	46.5	26
Tomato Paste, by heating (June)		74	20		90	0,773	100.0	26
Tomato puree (October)	-	92	15		20	0.002	21.6	8
Tomato paste, by heating (October)	-	75	28		100	0.700	98.7	25

CONCLUSION

Ascorbic acid is reduced in the tomato paste made by the production method under the influence of heat treatment (85-100°C), while vitamin C and other nutrients are preserved in the tomato paste made using ultrasound at a low temperature (46°C). Under the influence of 40 kHz 60 W ultrasound, tomato paste is sterilized at a temperature of 46°C, killing both aerobic and anaerobic microorganisms. The product processed using ultrasound is alive and valuable. The ratio of tomato and red sweet pepper (Capsicum annuum) is 21:1 to achieve daily amount for adults of vitamin C in 100 grams of tomato paste.

It was established: in the technical ripeness of the raw tomato fruits, the content of toxic elements - heavy metals (Pb, As, Hg) and nitrates (NO_3^-) are minimal - compared to other periods, so the technical ripeness is the best indicator for making tomato paste.

After processing of tomato paste using ultrasound, no additional sterilization is needed for canning. But previously sterilized cans must be used (every tool contacting with the product must be sterile).

The use of innovative technology allows saving electricity by 2.5 times, compared to the use of the classical method, and greatly simplifies temperature control, which ensures the accuracy of the desired temperature and less fluctuations in the production process.

The product was processed by ecologically clean technology. During processing no additional biologically active additives were used. Only citric acid which is available in the market was used to regulate acidity. Red sweet pepper was used to increase the amount of ascorbic acid in tomato paste. The obtained product is characterized by a high degree of naturalization, natural taste properties are preserved in it. It is biologically complete and ecologically pure. which is important for human existence.

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