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SHORT COMMUNICATION

EFFECTIVE COMPLEX PROCESSING OF RAW TOMATOES

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Abstract: Tomatoes grown in the central and southern parts of the country, which contain 5 - 6 % of solids, including 0.13 % of pectin, 0.86 % of fat, 0.5 % of organic acids, 0.5 % minerals, etc. are used as research material. These tomatoes, grown in the mountains, on soils with high salinity, contain high amounts of valuable components and have long term preservation. For the extraction of valuable components from dried tomato pomace, the CO_2 extraction method is applied. The technological and environmental feasibility of graded tomato drying in the atmosphere of an inert gas and in a solar drier is evaluated; the scheme of dried tomatoes production is improved; a system for tomato pomace drying is developed; a scheme of tomato powder production from pulp, skin and seeds is developed. The combined method of tomato pomace drying involves the simultaneous use of electromagnetic field of low and ultra-high frequency and blowing hot nitrogen on the product surface. Conducting the drying process in the atmosphere of nitrogen intensifies the process of removing moisture from tomatoes. The expediency of using tomato powder as an enriching additive is proved. Based on the study of the chemical composition of the tomato powder made from the Dagestan varieties, and on the organoleptic evaluation and physicochemical analysis of finished products, we prove the best degree of recoverability of tomato powder in the production of reconstituted juice and tomato beverages.

Keywords: *CO_2-extracts, drying agent, microwave drying, tomatoes, tomato pomace, tomato powder*

INTRODUCTION

The strategic objective of the country's agricultural policy is to increase the efficiency of agricultural production, including tomatoes [1]. Pursuant to this task, the fastest introduction of new advanced technologies of tomato processing plays an important role. These technologies will help to significantly reduce product losses [2]. However, canned food produced in Russia cannot compete in the international market due to the inefficient quality-to-price ratio of tomato products. Therefore, canned products quality improvement and reduction of their cost are essential factors in the development of industrial processing of tomatoes. This problem must be resolved primarily by fuller use of the natural potential of tomato raw material and increased adaptability of the manufacturing process.

However, the technology and mechanisms of influence of solar energy, microwave electromagnetic field, electroplasmolisis on raw tomatoes have not yet been studied well enough. The influence of CO_2 and ultrasound processing on vegetable stock in the course of technological processes also remains understudied. One of the major advantages of the technologies based on the use of low frequency electromagnetic field, ultrasound and CO_2 extraction is the opportunity to manufacture products without preservatives, fillers, chemicals, unwanted flavorings or other additives.

The solution of the problem of complex processing of raw tomatoes and production of competitive products lies in the introduction of innovative technologies based on physical, biological and technological methods, use of ultrasound, gas-liquid and electrophysical processes in processing raw materials and semi-manufactured products.

After the study of the known methods for long-term storage of raw materials, a gentler drying method is proposed to be applied to tomatoes. Dried tomatoes have good appearance and excellent taste. They can be used in home cooking and catering – in the preparation of a wide variety of dishes.

The aim of the research is theoretical justification and practical development of innovative technologies for complex processing of raw tomatoes using physical and chemical processing methods on the basis of CO_2 extraction, electromagnetic fields and ultrasound exposure.

To achieve this goal the following tasks are solved:

1) theoretical and experimental confirmation of the technological and ecological feasibility of using national tomato varieties in the production of pastes, purees, juices, CO_2-extracts and dyes;

2) theoretical justification of the use of innovative methods of physical and chemical processing of raw materials in the production of tomato products:

- electromagnetic fields of ultralow and ultrahigh frequencies;
- ultrasonic exposure.

Dry and half-dry tomatoes have high biological value, antioxidant activity and immune protection properties. Dried tomatoes contain biologically active substances in a highly concentrated form, lycopene, β-carotene, vitamin C, polyphenols and flavonoids. The high content of lycopene in the pulp and skin of tomatoes allows enriching other products with it.

The shelf life of fresh vegetable raw materials is limited, so it is necessary to develop gentle ways of preserving tomatoes allowing maximum conservation of valuable

components. In this view, the task of improving the method of drying with maximum preservation of physiologically valuable substances seems to be very urgent [3].

MATERIALS AND METHODS

The following tomato varieties were chosen as the object of research: Yuliana, Betta, Bychie Serdtse, Rally F1 Hybrid, Gnom, Dubrava, Zagadka, Lyana, Malinovaya Lampa, Tomat Rozovyi, Khurma, Tsifomandra as well as the hybrids of various varieties, composition and ripening periods grown in the plains and submountain regions of Dagestan.

According to the European standard, tomatoes should be clean, in apparent good condition, not damaged or rotten, without any foreign taste or odor, without any visible fibers of mould or discoloration, surface defects, spots covering more than 5 % of the surface. The exceptions are the flavors of sodium chloride and other condiments. Dried tomatoes should be in a condition good enough to withstand loading, unloading, and transportation and arrive at their destination in marketable state.

The use of the PDM methodology in the management of tomato products quality can be agreed with the requirements of the ISO 9000 international quality standard. The ISO 9001-2011 international standard "Quality Management System. Requirements" specifies the requirements for the management of a variety of data, information and processes. According to the standard requirements for quality management system, to operate successfully we can manage numerous interconnected types of tomato processing. Combining the requirements of ISO 9001 for data management and product data contained in the PDM system, which are also subject to control, the most important management requirements were selected by the example of dehydrated tomatoes production. The data are contained in the PDM system and make the most important contribution to the tomato quality increase. The result can be presented in the form of a product data management scheme based on the requirements of the ISO 9001 standard (Figure 1).

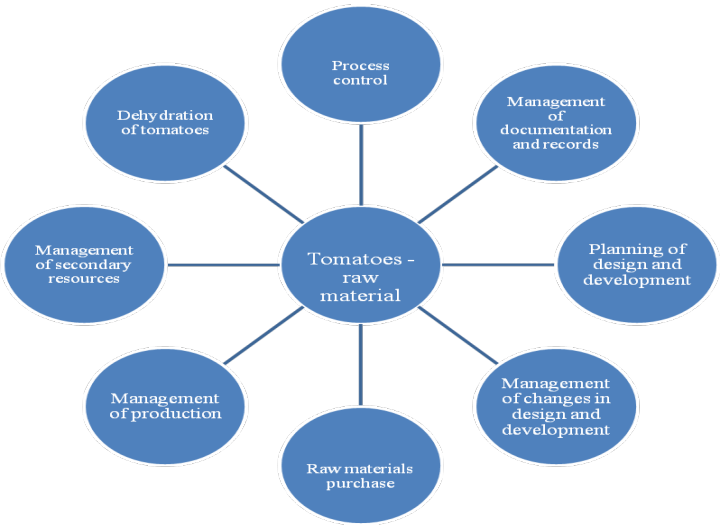

Figure 1. *Management of tomato processing data based on the requirements of the ISO 9001 standard*

By means of analyzing the main process's technological parameters, quality factors and product improvement measures, one can identify the points of the process in which the quality of the final product can be changed through the PDM system.
In the course of the research, original equipment and installations were used. Figure 2 shows the design of equipment for graded drying of tomato products.

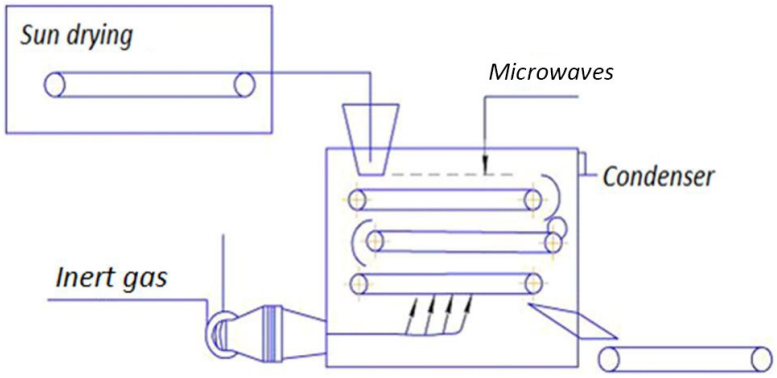

Figure 2. *Experimental dryer*

Experiment

The studies of the biochemical composition show that the tomato variety affects the quality of end products (Table 1).

Table 1. *Biochemical composition of some tomato varieties*

Variety	Content of soluble solids, [%]	Acidity, [%]	Sugar content, [%]	Vitamin C content, [mg %]
Dubrava (control)	5.5	0.61	2.62	24.7
Rally F1 Hybrid	5.9	0.63	2.84	25.9
Tomat Rozovyi	5.8	0.58	2.82	26.3
Malinovaya Lampa	5.7	0.57	3.12	26.2
Zagadka	5.6	0.52	2.93	25.7

A direct link is found between solids content in tomatoes and sugar concentration ($r = 0.95 \pm 0.2$).
According to the data given in the table, the soluble solids content in the tomato varieties was at 5.6 - 5.9 %. The lowest content of soluble solids was registered in the Dubrava variety (5.5 %), which was used as reference, the highest content (5.8 - 5.9 %) was recorded in the Rally F1 Hybrid, Tomat Rozovyi, Malinovaya Lampa, Zagadka varieties. The tomatoes grown in the southern regions of Dagestan are fully enriched with nutrients containing 5 - 6 % of solids, including 0.13 % of pectin, 0.84 % of cellulose, 0.5 % of organic acids, 0.6 % of mineral substances, etc. The tomatoes grown in the mountains on the soil with a large content of calcium are characterized by higher tissue density and longer shelf life. The tomatoes contain a large number of dietary fibers including pectin substances, macro- and microelements, vitamins, carotenoids as the most required nutrients.

Dietary fibers are polysaccharides of plant origin. They are considered an essential element for the removal of heavy metals and radionuclides from the body. They are able to activate intestinal peristalsis and metabolic processes in the body and remove metabolic products. Tomatoes contain large amounts of vitamin C, vitamins of the B group. Potassium salts, magnesium, calcium, copper, iron, selenium, phosphorus are beneficial to the hematopoietic system [4 – 6].
The diagram in Figure 3 shows the stages of raw tomato processing.

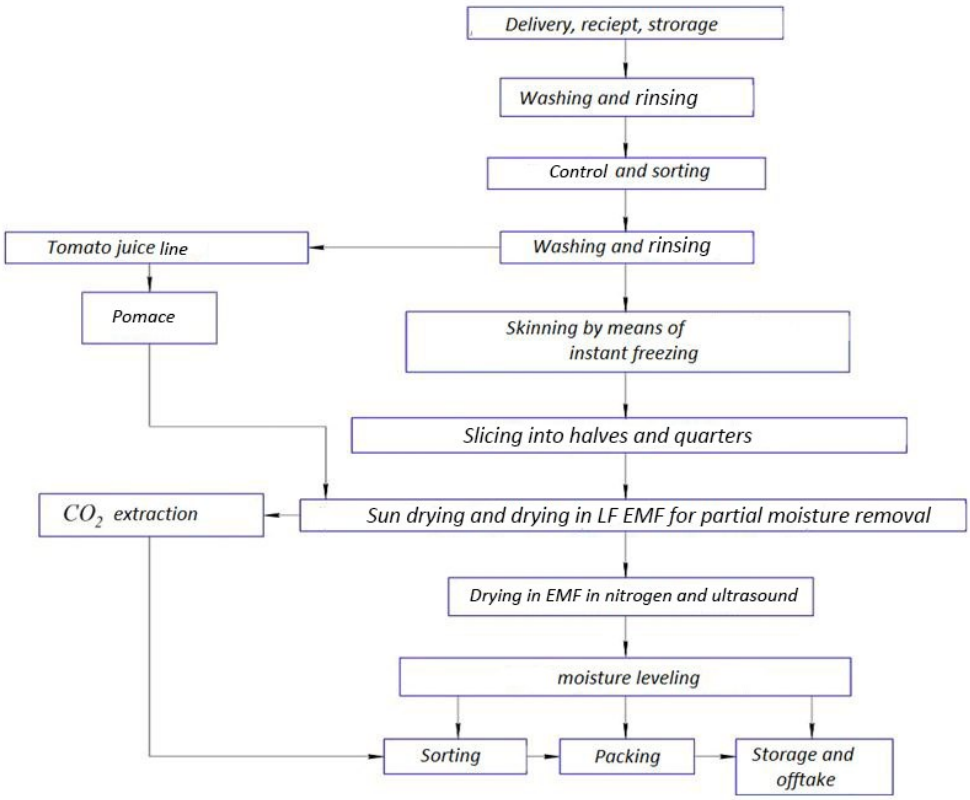

Figure 3. *Block diagram of raw tomatoes processing*

The use of the electromagnetic field (EMF) of low frequency (LF) and ultra-high frequency for the drying process intensification, ultrasonic processing of raw materials are the distinctive features of this scheme. The CO_2 extraction method is used for the extraction of valuable components from dried tomato pomace. Despite the fact that tomato products are very popular among the population, its shelf life in natural form is very limited. However, the cultivation and processing of tomatoes is a labor-intensive process. Pulpy tomato juice and tomato powder made from it are produced by separating skin and seeds from flesh with the use of a tomato pulper. Upon delivery to the plant, tomatoes are washed, crushed, pulpified and boiled down to 26 - 30 % of solids in a vacuum evaporation machine. Boiled pulp is sprayed in a spray dryer under pressure. Simultaneously, 2 % starch powder is added to the sprayed pulp. This method allows improving the adhesiveness of the powder agglomerates exiting the dryer.

RESULTS AND DISCUSSION

In order to improve the tomato processing technology, we analyzed the possibility of drying tomatoes in gentle technological modes which preserve the valuable raw material components. It is established that the microwave drying process in an inert gas atmosphere allows obtaining high quality products.

The kinetics of the tomato drying process was studied with the aim of developing a gentler technology of raw tomato drying with maximum preservation of the original useful properties. As can be seen from Figure 1, the advanced technology allows drying chopped tomatoes and tomato pomace with maximum preservation of biologically active substances.

For the first time, low frequency EMF processing was used in practice for intensifying the technological process of mass transfer of moisture from the inner layers of the material [4]. Microwave drying is also a promising method. When semi-manufactured tomatoes are heated by means of microwaves, the material absorbs the 12.2 wavelength electromagnetic energy which transforms into heat energy.

The combined method of tomato pomace drying consists in the simultaneous use of the electromagnetic field of low and ultra-high frequencies together with blowing hot nitrogen on the product surface. Performing the drying process in nitrogen intensifies the process of removing moisture from raw tomatoes (Figure 4).

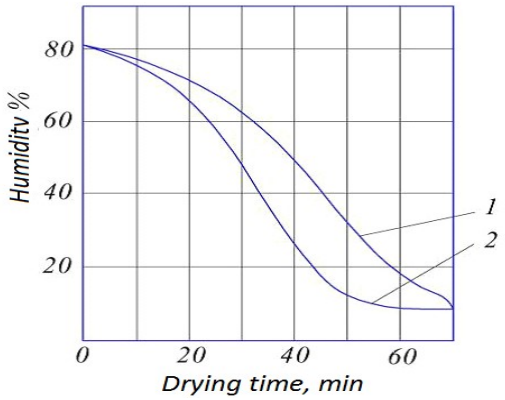

Figure 4. *Curves of tomato pomace drying:*
1 - in inert gas; 2 - in inert gas in LF EMF

The use of this method reduces the loss of biologically active substances. The total chemical composition of tomato powder is shown in Table 2.

Table 2. *Total tomato powder chemical composition, [%]*

Tomato powder	Moisture	Fat	Protein	Ash	Carbo-hydrates total	Including	
						Pectin	Cellulose
Research results	3.1	0.43	12.9	8.9	58.2	1.2	16.5
Control	4-7	0.1-0.4	10-12	7-10	40-57	0.8	8.7

100 g of tomato powder also contain 80 mg of carotenoids, including 35 mg of β-carotene and 42 mg of lycopene, and 352 mg of ascorbic acid.

One of the most important characteristics of tomato powder is its recoverability, i. e. the ability to absorb moisture and recover the properties of natural vegetable raw materials. The experiments determined the degree of tomato powder recoverability at various dosages of water (from 1:1 to 1:8) best suited for use in manufacturing various products. The duration of powder swelling amounted to 30 min. Due to the chemical composition of tomato powder, the addition of 10 % of hydrated powder to a product results in 100 g of the product containing 0.22 g of dietary fibers. It does not fully satisfy human daily requirement, but indicates an increase in the product's nutritive qualities. The additional functional components in this case are carotenoids, macro- and micronutrients, and vitamins [7, 8]. Tomato powder can be used for the production of dry seasonings, sauces, juices, dry soups and chips.

CONCLUSION

The proposed complex tomato processing technology for dried tomatoes, and dry tomato powders is recommended for introduction into manufacturing.

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