Study of the influence of electromagnetic processing on the physiological state and duration of storage of tomato fruits

I Sh Dzakhmisheva¹, A Ya Tamakhina¹ and A A Akbasheva²

¹ Kabardino-Balkarian State Agrarian University named after V.M. Kokov, 1v, Lenin pr., Nalchik, 360030, Russian Federation
² Moscow Financial and Industrial University “Synergy”- Karachayevo-Cherkesskiy Branch, 83, Lenin str., Cherkessk, 369000, Russian Federation

E-mail: irina_dz@list.ru

Abstract. The scientific article presents the results of a study of the effect of treatment in an electromagnetic field of a self-generated discharge arising in high-current gas-discharge plasma with different exposure times on the shelf life of tomato fruits. The dynamics of the content of antioxidants and phenolic compounds in tomato fruits as a result of electrophysical processing was revealed. As a result of processing tomatoes in the electrophysical field of a self-generated discharge for 7 seconds, high values of the content of antioxidants and phenolic compounds are maintained throughout the entire storage period. Electrophysical processing of tomatoes for 120 and 180 seconds led to a significant decrease in the content of antioxidants and phenolic compounds comparable with the untreated sample. It has been established that the technology of electromagnetic processing of tomato fruits allows you to increase their shelf life up to 14 days compared with the control sample (10 days), increase resistance to fruit damage by phytopathogens, due to a decrease in the synthesis of phytoalexins during storage. The proposed technology will increase the storage efficiency of tomato fruits, preserving their physiological state, taste and biologically active substances useful for the human body at all stages of product distribution from producers to consumers.

1. Introduction

Tomatoes are one of the popular and favorite vegetables used in cooking. Tomatoes have high nutritional value, but at the same time low keeping quality. The nutritional value of tomatoes is due to the content of a large number of substances important for the human body: sugars, vitamins, organic acids, enzymes, mineral salts, fiber, pectin, volatile, carotenoids and other biologically active substances. Tomato fruits have high palatability, but the process of receiving tomatoes from producers to consumers takes a long time, and when stored their consumer properties are reduced. Fruits of tomatoes belong to low-light products. The period of consumption of tomatoes from open ground coincides with the period of ripening in the field. Modern technologies for growing tomatoes are able to provide fresh fruits from open ground only for 1.5-2.5 months a year. To extend the period of consumption of fresh tomatoes from open ground, it is most advisable to apply technologies that increase the shelf life.

2. Problem statement

An important problem is the preservation of the physiological state, taste, and biologically active substances of tomato fruits useful for the human body at all stages of product distribution from
producers to consumers for a long period of time. During storage of ripe tomatoes, the ability to form phytoalexins is significantly reduced. This is due to a change in the physiological state in the postmenopausal period and a decrease in the activity of 3-hydroxy-3-methylglutaryl-CoA reductase. As the fruits are stored, their ability to produce phytoalexins decreases, which is consistent with a decrease in the resistance of the fruits to diseases [7]. Physical processing factors affect the physiological state and persistence of fruits and vegetables [5]. To preserve the entire abundance of nutrient and biologically active substances, to extend the shelf life of tomato fruits, we use the developed technology of electrophysical processing of fruit and vegetable products [2,3,6,8,10,11]. A distinctive feature of this technology is that the processing of tomato fruits proceeds at a temperature of 20 ºС in the electromagnetic field of a self-generated discharge arising in high-current gas-discharge plasma with different exposure times. The aim of the scientific work is to study the effect of electromagnetic processing on the physiological state, the shelf life, and the shelf life of tomato fruits.

3. Materials and methods
Ripe tomato fruits without signs of deterioration and withering with a soft and juicy consistency were selected as objects of study. For each variant of the experiment, including control, 20 tomato fruits of Rio Grande were studied. Analytical repetition was conducted three times.

3.1. Electro-physical method
To study the effect of electro physical processing on the preservation of nutrients and useful properties, the increase the shelf life of tomato fruits, a plasma electromagnetic device was used [4]. The essence of the method is that the fruits of the tomatoes were processed in the electromagnetic field of a self-generated discharge arising in a high-current gas-discharge plasma with different exposure times (7, 120 and 180 seconds) at a temperature of 20 ºС. The physiological state of control samples of fresh tomato fruits on the 7th day of storage deteriorated, the onset of microbiological spoilage was observed, and after 10 days, strong signs of fruit damage by rot were detected.

As a result of processing the tomato fruits in an electromagnetic field for 7 seconds, the appearance was preserved, there were no signs of deterioration and withering, and a soft and juicy consistency was maintained for 14 days of storage.

Fruits processed in an electromagnetic field for 120 seconds on the 14th day of storage were characterized by the preservation of consumer properties, but signs of wilting were observed.

The processed tomatoes in an electromagnetic field for 180 seconds on the 14th day of storage had softening of the pulp without significant signs of spoilage.

3.2 Method of amperometric detection
It is known that tomato fruits are rich in antioxidants which, along with other nutrients, are an integral part of a healthy human diet. In this regard, it is important to study the effect of electrophysical processing on the content of antioxidants (flavonoids, benzoic acids, cinnamic acid, phytoestrogens, and carotenoids) in tomatoes [9]. For this, the amperometric detection method was used which allows direct measurement of the content of all antioxidants in the sample [1]. This method is based on electrochemical reactions of oxidation and reduction of substances. Using the Blizar antioxidant analyzer with an amperometric detection module, a Simplicity type I of high-purification water system and an automatic single-channel dispenser the dynamics of antioxidant content in tomato fruits processed in an electromagnetic field for 7, 120 and 180 seconds was determined (see Figure 1).

3.3 Method of gas-liquid chromatography
It is known that phenolic compounds have high physiological activity and play an important role in human life. The residual content of phenolic compounds must be controlled during long-term storage of fruits and vegetables. One of the most widely used methods for determining the content of phenolic compounds in tomato fruits is gas-liquid chromatography. The method is based on the physicochemical separation of the analyzed components which allows quantitative determination of substances in a complex mixture. For analysis small amounts of the substance of tomatoes processed in an electromagnetic field for 7, 120, and 180 seconds were selected (see Figure 2). The study was carried out on a “Svet-152” gas-liquid chromatograph with a high threshold of detector sensitivity.
which operates in the programming mode of column temperatures in the temperature range from 50 to 400 °C. Helium was used as the carrier gas. The constant flow rate of the carrier gas was 75-100 cm$^3$ / min. With the help of a katharometer a change in the thermal conductivity of the carrier gas was recorded due to the appearance of the analyte.

4. Discussion of the results

Electromagnetic processing of tomato fruits for 7 seconds allowed increasing the shelf life of tomato fruits (see Figure 3). At the same time, there was no deterioration in their organoleptic quality indicators (appearance, color, smell, texture, taste). The study of the effect of electromagnetic processing of tomato fruits on the content of antioxidants and phenolic compounds and their storage duration allowed us to establish that tomato samples processed in the electromagnetic field of a self-generated discharge for 7 seconds have higher values of the content of antioxidants and phenolic compounds in comparison with samples of tomatoes processed in an electromagnetic field for 120 and 180 seconds. However, during storage, there was a decrease in the content of both antioxidants and phenolic compounds in all variants of the experiment.
Figure 3. Dynamics of the shelf life of tomato fruits, depending on the effect of the electromagnetic field of a self-generated discharge for 7, 120 and 180 seconds.

5. Conclusion

It has been established that an effective way to extend the shelf life of tomato fruits is to process them in the electromagnetic field of a self-generated discharge for 7 seconds. The electromagnetic processing method allows you to increase the shelf life of tomatoes from 7 to 14 days compared to control samples. The achieved results include an increase in the shelf life of tomato fruits while maintaining their physiological state, taste and biologically active substances useful to the human body at all stages of product distribution from producers to consumers. The increase in the shelf life of tomatoes is due to a direct dependence on the content of antioxidants and phenolic compounds in the studied samples. The technology of electromagnetic processing of tomato fruits allows you to increase resistance to fruit damage by phytopathogens due to a decrease in the synthesis of phytoalexins during storage.

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