Development of technological solutions for canning small-fruited tomatoes

A A Potapova and S A Rodikov

Michurinsk State Agrarian University, 101, International st., Michurinsk, 393760, Russia

E-mail: potapovaalla@mgau.ru

Abstract. Small-fruited varieties of tomatoes have high taste and are significantly superior to large-fruited ones. The variety for the production of canned whole-fruit tomatoes primarily influences the shape and size of the fruit, shape index, ratio of the fruit parts, peel, pulp and seeds, peel condition, as well as the content of solids, carotenoids and their composition, which significantly affects the quality and color of the finished product. In this regard, the consumer and technological properties of 7 varieties of small-fruited tomatoes were studied. Based on the results obtained, a well-grounded conclusion was made that new varieties of small-fruited tomatoes are not inferior in terms of the studied indicators to large-fruited ones and can be recommended for expanding the range of a similar type of domestic canned production.

1. Introduction

Vegetables are essential raw materials for processing industry as they are a powerful regulator of health. The food industry focuses on expanding the range of products by attracting new types of raw materials and developing new non-traditional production technologies for the consumer market. Food enrichment with vitamins, macro- and microelements is a serious interference in the traditionally established structure of human nutrition. The need for such intervention is dictated by environmental factors associated with changes in the composition and nutritional value of food products as well as with a decrease in energy consumption [1-6].

Manufacturing food products including those with a high content of vitamins and biologically active substances requires a systematic approach. The technology for creating products with a high content of biologically active substances implies activities to minimize oxidation and thermal decomposition of vitamins and other valuable natural components. It is necessary to choose the right temperature, heat treatment time taking into account the characteristics of raw materials and biochemical parameters [7-11].

We tested 7 varieties of small-fruited cherry tomatoes classified as semi-cultivated subspecies with the objective to expand the range, improve the consumer properties of domestically produced whole canned tomatoes. The fruits of the studied varieties are distinguished by a wide range of shapes, colors and sizes, and are distinguished by the increased nutritional value because accumulate more biologically active substances [12, 13].

The main disadvantage of some small-fruited varieties of tomato is the cracking of the fruit when canning, peel coming off and pulp getting into the filling. The shape of the fruits, their size, the
content of seeds and locules are important in the production of canned tomatoes. Peel thickness is of paramount importance as well.

Different tomato varieties are sensitive to cracking in different ways. Large-fruited varieties are especially prone to cracking. Low locular tomatoes and the ones with a smooth surface crack more than multilocular tomatoes and those with slightly ribbed ones with a strong color intensity before ripening.

In the process of canning, the tomato peel integrity can be violated (cracking, partial slipping) and pulp can be mashed. To avoid this, crystalline calcium chloride (pharmacopoeial) is added to the drilling fluid – 0.16% to the mass of the pulp (0.09% to the mass of canned food). Calcium chloride forms insoluble calcium pectate with pectin contained in tomatoes, which strengthens fruit tissues.

In this regard, the purpose of the research was to evaluate small-fruited tomato varieties for their suitability for whole-fruit canning and to optimize individual technological processes in order to improve their consumer and technological characteristics.

2. Materials and methods
The objects of research were 7 small-fruited tomato varieties: Korolek, Noble Prince, Mini Bell, 10-Fruit Grape, Golden Drop, Orange Cream, Black Moor, Mini Bell. The tomatoes were grown in the open ground of the Central Black Earth Region.

Tomatoes were grown at the instructional farm “Roscha” of Michurinsk State Agrarian University according to the technology adopted in the farm. The average fruit weight was determined at each harvest by weighing 10 fruits. The organoleptic assessment of the quality of the obtained canned food was carried out according to a 10-point rating scale and with regards to the coefficients of significance. Biochemical analyses were performed in the biochemical laboratory of the university. The mass fraction of dry substances was determined by drying them to constant weight, sugar – according to Bertrand, total acidity – by titration with 0.1 mol/dm³ alkali, ascorbic acid – by iodometric method, calcium – by complexometric method, the content of pectin substances (water-soluble and water-insoluble) – by calcium pectate method.

In the process of technology development, experimental batches of small-fruited canned tomatoes were developed by adding calcium chloride to the filling and without adding it, 100 cans from 6 studied varieties of small-fruited tomatoes. The tomatoes were canned with regards to the generally accepted technology.

3. Results and Discussion
Organoleptic and physicochemical studies of canned small-fruited tomatoes revealed significant discrepancies in terms of the appearance and consistency of fruits. These discrepancies are decisive in determining the commercial quality. Canned fruits should not be mashed or have cracked or slipped peel. In this regard, the studies determined the number of fruits with cracked peel in canned food without and with the addition of calcium chloride.

The main defect of ready-made canned tomatoes produced in accordance with GOST is a high percentage of tomatoes with cracked, rolled, and sometimes slipped peel.

This is stipulated by the resistance of the cytoplasmic membranes of the peel cells and the adjacent layer of tomato pulp to a hot solution of filling and pasteurization during canning. As a result, the peel cracks and even rolls and slides off the fruit, which creates an unmarketable look of ready-made canned food.

In existing technologies, this problem is handled by fruit blanching with hot water within the temperature range from 70 to 980°C with a different period of blanching time.

Blanching at a temperature of 98°C for 1-3 minutes destroys the cytoplasmic membranes of cells, sharply increases the cell permeability of the peel but negatively affects the pulp of the fruit, specifically, the pulp mashes.

Blanching at a temperature of 70-80°C for 5-7 minutes excludes boiling but does not give the desired effect to increase cell permeability and reduce fruit cracking.
To eliminate this problem, we used blanching at a temperature of 70-80°C and adding calcium chloride into the filling (0.1, 0.2, 0.22, 0.25, 0.3%).

When adding 0.22% calcium chloride and providing the following temperature conditions: blanching at 75°C and pasteurization at 95°C, the desired result was obtained, specifically, a 75-90% reduction of large cracks, rolled and slipped peel. At the same time, the number of small cracks (a network of cracks) increased on the surface of the fruit, while the pulp of the fruit became denser and, practically, there were no pulp particles in the filling.

The physicochemical study of tomato fruits preserved by this method, indicated that the calcium content increased almost by 2 times, the content of pectin substances increased by 1.2-1.5 times. In addition, the composition of pectin substances changed due to the formation of pectates being complex compounds of pectins with calcium, which, obviously, changed the structure of tissues and peel, and in combination with temperature modes of blanching 70-75°C and pasteurization 95°C, contributed to an increase in the permeability of peel cells. As a result, the cytoplasmic membranes of the peel and tissues were destructed more evenly, a small network of cracks formed on the surface of the peel. Salt, sugar and other filling ingredients freely diffused through these cracks practically eliminating fruit cracking, peel separation, mashing of the adjacent layer of pulp and entering pulp particles into the filling (Table 1).

**Table 1.** Presence of fruit defective in consistency depending on calcium and pectin substances in canned tomatoes with the addition of CaCl₂.

| Small-fruited tomatoes, canned with 0.22% CaCl₂ in filling in bb111-82-500 varieties: | Mass fraction in fruits, % | Number of defectives fruits (with visible cracks and slipped peel) |
|---|---|---|
| | calcium | pectin substances | total fruits in a jar, pcs. | pcs. | % |
| Korolek | 12.1 | 1.02 | 48-49 | 4 | 8.2 |
| Noble prince | 11.3 | 1.26 | 19-20 | 1 | 5.1 |
| Mini Bell | 14.1 | 1.43 | 19-20 | 1 | 5.1 |
| 10 fruit grapes | 14.2 | 1.39 | 15-16 | 1 | 6.4 |
| Golden drop | 10.08 | 1.09 | 22-23 | 1 | 4.4 |
| Orange cream | 11.01 | 1.31 | 11-12 | - | - |
| Black moor | 11.6 | 1.34 | 12-13 | - | - |
| Control Mini Bell (without adding calcium chloride to the filling) | 10.2 | 1.12 | 19-20 | 12 | 63.1 |

As a result of the research, it was found that the addition of 0.22% calcium chloride to the filling led to an increase in the content of calcium and pectin substances in all canned food studied. The content of pectin substances in canned food increased by 0.15-0.33%.

As a result of the organoleptic evaluation of canned whole-fruit tomatoes, it was found that the fruits of the Orange Cream, Golden Drop and 10-Fruit Grapes varieties received more than 9 points, which corresponds to excellent quality.

The rest of the tomato varieties in canned whole fruits received from 8.17 to 8.8 points, which corresponds to good quality.

The decrease in scores in canned food concerning the varieties Korolek and Noble Prince was mainly due to the weak typicality of the taste. Comparing the organoleptic indicators with the control, it was found that the decrease in points for the control occurred due to the indicators of fruits consistency and entering of the pulp into the filling, due to which its transparency deteriorated.
In general, of all the studied varieties, the obtained canned food had good taste. The taste of the canned food was harmonious; the aroma was pronounced, and corresponded to the tomato fruits from which the canned food was obtained, had no foreign taste and smell.

It should be noted that during taste assessment, the following indicators had the greatest influence on the quality of the studied canned food: taste, appearance, aroma and fruit consistency.

Table 2. Vitamin premix of canned food

| Canned food made from studied varieties | Ascorbic acid content, mg/100g | Carotenoids, mg/100g, including: | sum | β-carotene | lycopene |
|----------------------------------------|--------------------------------|----------------------------------|-----|------------|---------|
| Korolek                                | 24.06                          | 12.3                             | 2.5 | 9.0        |
| Noble prince                           | 22.8                           | 9.0                              | 3.5 | 5.2        |
| Mini Bell                              | 21.3                           | 9.5                              | 1.1 | -          |
| 10 fruit grapes                        | 30.9                           | 18.3                             | 5.1 | 12.3       |
| Golden drop                            | 27.0                           | 2.0                              | 1.3 | -          |
| Orange cream                           | 33.0                           | 12.0                             | 4.3 | 7.4        |
| Black moor                             | 20.3                           | 9.0                              | 5.1 | 3.8        |
| Control Mini Bell (without adding calcium chloride to the filling) | 30.9 | 18.3 | 5.1 | 12.3 |

In canned tomatoes, the content of ascorbic acid ranges from 20.3 to 33.0 mg/%. When subject to technological processing of tomatoes, the loss of vitamin C, as well as other vitamins ranges from 34.5 to 45.2%, which is typical for thermal processes of blanching and pasteurization and is similar to the loss of vitamin C during canning of other types of vegetables and fruits. Calculations have shown that with the use of 100g of canned food, the daily requirement of the human body for ascorbic acid can be replenished by 29.0-47.1%.

The canned food prepared from the varieties Mini Bell (18.3 mg/100 g), Korolek (12.3 mg/100 g) and Grapes 10 fruit (12.0 mg/100 g), which replenish the daily requirement of the human body by 366%, 246% and 240%, respectively, contained the maximum total amount of carotenoids.

According to the content of lycopene in canned food, the daily requirement of the human body can be replenished from 76% (in the Black Moor variety) to 246% (in the Mini Bell variety).

4. Conclusion

Based on the studies, the production of pasteurized canned food is considered advantageous, since the obtained canned food has good organoleptic characteristics and a high content of biologically active substances, and the loss of nutrients during their production is much lower, which enables to recommend this method of canned food production for obtaining a product with a high content of biologically active substances.

References

[1] Chernaya A E, Kabanenko M N, Ugrimova S N 2019 Improvement of agro-industrial complex management at the federal level *IOP Conference Series: Earth and Environmental Science* **274**(1) 012073

[2] Minakov I A and Nikitin A V 2019 Agricultural market development: Trends and prospects *International Journal of Innovative Technology and Exploring Engineering* **9**(1) 3842-3847

[3] Gharehbeglou P, Jafari S M 2019 Antioxidant Components of Brassica Vegetables including Turnip and the Influence of Processing and Storage on their Anti-oxidative Properties *Current Medicinal Chemistry* **26**(24) 4559-4572
[4] Ronga D, Pentangelo A, Parisi M 2020 Optimizing fertilization to improve yield, technological and nutritional quality of tomato grown in high fertility soil conditions *Plants* **9**(5) 575

[5] Bacenetti J, Negri M, Duca D, Fiala M 2015 Environmental impact of tomato purée: Anaerobic digestion of by-products as mitigation strategy *Procedia Environmental Science, Engineering and Management* **2**(3) 169-175

[6] Suhareva T, Sergienko I, Kutsova A and Ratushny A 2019 Mathematical planning when choosing rational dosages of ingredients for adjusting the composition of bakery products *International Journal of Engineering and Advanced Technology* **8**(6) 4562-4565

[7] Lyashchuk Yu O, Novak A I, Kostrova Yu B, Shibalshina O Yu, Evdokimova O V, Kanina I V 2021 The study of persistence of microorganisms and parasites in food products *IOP Conference Series: Earth and Environmental Science* **640**(6) 062002

[8] Perfilova O V, Akishin D V, Vinnitskaya V F, Danilin S I, Olikainen O V 2020 Use of vegetable and fruit powder in the production technology of functional food snacks *IOP Conference Series: Earth and Environmental Science* **548**(8) 082071

[9] Blinnikova O M, Babushkin V A, Akindinov V V, Perfilova O V and Novikova I M 2020 Production technology and mathematical method for modeling the formulation of fruit and jelly candies enriched with collagen *IOP Conference Series: Materials Science and Engineering* **919**(5) 052036

[10] Eliseeva L G, Akishin D V, Potapova A A 2010 Consumer properties of small-fruited tomatoes and expanding the range of domestic canned products *Commodity expert of food products* **11** 29-34

[11] Potapova A A 2018 Evaluation of consumer properties of small-fruited varieties of pepper *New technologies* **4** 68-73

[12] Potapova A A 2019 Commodity characteristics of small-fruited varieties of pepper *Vestnik KrasGAU* **2** 157-160

[13] Potapova A A 2018 Consumer properties of small-fruited tomatoes for canning *New technologies* **4** 74-78