Study of technological properties of apples for jam production

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Abstract. The work is devoted to the study of the fruits of winter and autumn apple trees grown on the territory of the Belgorod region. The results of research of technological indicators of apple quality are presented. According to the results of the tests carried out, it was found that the fruits of the Zhigulevskoe variety turned out to be the best in terms of a set of indicators: the dry matter content was 15.4%, sugars - 12.3%; organic acids - 1%, sugar-acid index - 12.3 units; concentration of vitamin C - 13.9 mg / 100 g; R - active substances - 110 mg / 100 g; the total amount of pectin substances - 6.4%, including 1.1% - water-soluble pectin. The efficiency of the technology for the production of apple jam with the addition of strawberries from fruit and berry raw materials obtained in the conditions of the Belgorod region has been substantiated.

1. Introduction

Today, over 20 thousand varieties of apple trees grow in various climatic zones. World production of apples and pears is just over 77.0 million tons. Of these, China accounts for 57%, or 43.9 million tons, EU countries - 17% (13.1 million tons), the United States - 6% (4.6 million tons), Turkey - 4% (3.1 million tons) and India - 3% (2.3 million tons). In the total volume of apples, winter varieties account for 60%, autumn - 25%, summer - 15%.

Among the EU countries the share of the main producers is: Poland, Italy, France and Germany. They give 9.8 million tons of fruit. The leading positions in apple production in the world among the countries outside the EU are occupied by China, the USA, Turkey, Brazil, Russia, Argentina, and Ukraine.

In Russia, over 95% of the gross harvest of pome crops falls on apple fruits, the remaining volume - on pears and quince; which are cultivated by more than 170 large horticultural organizations with a total garden area of over 100 hectares.

On the territory of the Belgorod region, the share of pome crops in the production of fruits and berries is about 73.0%. Since 2010, the gross harvest of apples and pears is at least 22.0 thousand tons of fruits from an area of 3.6 thousand hectares [1-2].

On average, the fruits of some apple varieties in the Central Black Earth region accumulate up to 1.78% organic acids, up to 0.47% tannins and dyes, up to 974 mg% P-active substances, 0.3 mg% PP, B 1 and B 2, as well as minerals: 248 mg / 100 g of potassium, 26 mg / 100 g of sodium, up to 8% fructose, up to 6.7% glucose and 4.5% sucrose, 0.7% organic acids and up to 1, 8% pectin, up to 28 mcg% iodine. The average content of vitamin C in apple fruits is 15-18 mg%, folic acid - 0.15 mg%
and catechins - 0.2-0.3%. Apple varieties with yellow pulp accumulate up to 0.5 mg% carotene. Moreover, 23 genes are highly correlated with the content of anthocyanins [3].

The concentration of dry matter by a quarter of the level depends on the amount of precipitation and air temperature during the period of fruit loading and by 20% on the biological characteristics of the variety. The amount of pectin in apple fruits is determined only by 6% by the cultivation conditions and by 23.3% by the variety [4].

At the same time, calcium-containing fertilizers help to improve the hardness of apples and their keeping quality. At the same time, calcium is concentrated more in the peel and core than in the pulp of the fruit, regardless of the method of application of agrochemicals. However, such fertilizers do not affect the content of soluble dry substances and titratable acidity of the apple [5].

Storage of autumn varieties of apples WELSIE and ZHIGULEVSKOE at a temperature of + 2 ° C in a modified atmosphere allows you to preserve the food quality of raw materials. The use of polyethylene liners helps to reduce weight loss, preserve vitamin C, pectin, organic acids, sugars and increase shelf life [6].

The study of the biochemical characteristics of domestic raw materials is especially important in different climatic conditions.

Taking into account the above, the purpose of the research was to study the technological properties of apple fruits in autumn and winter ripening in the Belgorod region in order to assess the possibility of their suitability for various types of processing and use in food production.

The fruits of the considered apple varieties are sold in the retail trade network of the city of Belgorod.

2. Materials and methods
The objects of research were the fruits of apple trees of 6 varieties of foreign and domestic selection growing on the territory of the Belgorod region: Aidared (autumn), Gala (winter), Golden Delishes (winter), Zhigulevskoe (autumn), North Sinap (winter), Spartan (autumn) and the most frequently supplied for sale in the trading network of the Belgorod region.

In the conditions of the Central Black Earth Region, the variety Zhigulevskoe is classified as a high-yielding and high-yielding variety on dwarf rootstocks with high commercial qualities [4].

To achieve this goal, the generally accepted methods were used. The main stages of testing were carried out on the basis of the Department of Production Technology and Processing of Agricultural Products of the Faculty of Technology and the experimental shop of the Belgorod State Agrarian University.

To process the research results, we used modern methods for calculating the statistical reliability of measurements based on the Microsoft Excel software package.

3. Results
At the first stage of the research, it was determined that the quality indicators of apple fruits of the studied varieties corresponded to the requirements for the 1st variety in accordance with Gost R 54697-2011 “Fresh apples sold in the retail trade network”.

At the second stage of testing, the study of the peculiarities of the chemical composition of apples, which characterize their nutritional quality, was carried out.

The varietal characteristics of fruits were determined by the accumulation of soluble solids and sugars (table 1).

Among the studied samples, a high accumulation of dry substances is characteristic of the varieties Golden Delishes (16.0%), Severny Sinap (15.6%), Zhigulevskoe (15.4%), as well as the Gala variety (14.8%).

In terms of the total sugar content, a higher indicator in the fruits of varieties Golden Delishes, Zhigulevskoe and Severny Sinap, the value of which was more than 12.0%.
Table 1. The chemical composition of apples in the Belgorod region.

| Variety                  | Dry matter | Sugars |
|--------------------------|------------|--------|
| Idared (autumn)          | 13.0       | 10.4   |
| Gala (winter)            | 14.8       | 11.8   |
| Golden Delishes (winter) | 16.0       | 12.8   |
| Zhigulevskoe (autumn)    | 15.4       | 12.3   |
| North Sinap (winter)     | 15.6       | 12.1   |
| Spartan (autumn)         | 13.8       | 11.0   |

The varietal specificity of apple fruits is also revealed in the level of accumulation of organic acids (figure 1). According to the indicator under consideration, apples of varieties Zhigulevskoe (1%) and North sinap (1.2%) are distinguished.

![Figure 1. The content of organic acids and the sugar-acid index in apples in the Belgorod region.](image)

Fruits with an optimal ratio of sugars and organic ones are characterized by good taste and a wide range of flavors. The sugar-acid coefficient is an indicator of fruit ripeness [7].

Apples of the Severny Sinap variety, where the sugar-acid index is minimal (no more than 10.1 p.u.), had a sour taste. Sweet and sour taste with a sugar acid index of 11.6-18.3 p.u. observed in fruits of the varieties Aidared, Gala, Zhigulevskoe and Spartan.

Sweet taste with a sugar acid index of 25.6 p.u. distinguished the variety Golden Delishes.

Apples are characterized by high consumer demand. Of practical interest is the study of the antioxidant activity of fruits, which is formed due to the vitamin complex together with polyphenols and phenol carboxylic acids.

Of the vitamins accumulated in apple fruits, the maximum antioxidant activity is observed in ascorbic acid, varying over a wide range. The considered varieties contained from 9.8 to 13.9 mg / 100 g of ascorbic acid (figure 2).

The varieties Gala, North Sinap and Zhigulevskoe, which contained vitamin C in an amount of over 13.0 mg / 100 g, stood out.

The accumulation level of P-active substances varied depending on the apple variety. The maximum content of these compounds was noted in the varieties AIDARED (109 mg / 100 g), Zhigulevskoe (110 mg / 100 g), SPARTAN (117 mg / 100 g) and GALA (121 mg / 100 g) (figure 3).
Pectin substances are present in fruit raw materials in the form of the sum of insoluble protopectin, pectic acid and soluble pectin compounds (figure 4). Their highest concentration was noted in the variety Zhigulevskoe (6.4%), where 1.1% of soluble pectin and 5.3% of pectinic acid protopectin were found.

Studies have shown that the fruits of apple trees are nutritious plant raw materials with a high content of biologically active substances. The consumption of fresh fruit and berry products by the population is limited to a rather short period. To preserve the maximum amount of nutrients, the grown raw materials are sent for canning. The inclusion of properly prepared canned food in the diet improves the quality of nutrition in the winter-spring period. The domestic market for canned fruits and berries is one of the largest in the world. Today, there is an increase in the share of production of these products by Russian companies, the number of which is more than 100 units. Organizations from Armenia, Greece, France and Germany prevail among foreign manufacturers.
Apples have high technological qualities: good gelling pectin, optimal combinations of sugars and free acids - in this connection, they serve as the main raw material in the production of compotes, juices and jams [8].

Strawberries were used as a blending additive. In modern conditions, strawberries are recognized as one of the economically profitable berry crops in horticulture [10]. It is appreciated for its exceptional aroma, excellent taste, high content of vitamins C and P - active catechins, anthocyanins, organic acids. Therefore, strawberries are actively used for canning and freezing [11-12].

Evaluation of the properties of plant raw materials, the quality of finished samples of jam was carried out in accordance with generally accepted methods for determining the quality indicators of fruits, berries and products of their processing.

In the technology for the production of canned fruit, apples of the Zhigulevskoe variety were used as the main raw material, and a varietal mixture of strawberries was used as an additive. The quality of the apple trees received for the production of jam samples corresponded to the requirements of GOST 27572-2017 “Fresh apples for industrial processing. Specifications”, strawberries - GOST 33953-2016 "Fresh strawberries. Technical conditions". The results of the organoleptic assessment showed the full compliance of the fruit and berry raw materials for processing.

Separate physicochemical parameters were determined for strawberries. The evaluation results are presented in (table 2).

Analysis of the information in (table 2) showed that strawberries are a good source of vitamin C, but they are poor in pectin substances.

When assessing the suitability of vegetable raw materials for the manufacture of jam workings, the ability of fruits and berries to form a thick gelling mass of natural color and aroma was taken into account [13-15].

**Table 2.** Physicochemical indicators of the quality of strawberries.

| Index                                | Raw materials                       |
|--------------------------------------|-------------------------------------|
| Mass fraction,%                      |                                     |
| Dry matter                           | 8.43±0.38                           |
| Sugars                               | 6.58±0.30                           |
| Organic acids (in terms of malic acid)| 1.12±0.05                           |
| Pectin substances                    | 0.7±0.03                            |
| Vitamin C content, mg / 100 g (iodometric method) | 55.7±2.5                           |
4. Discussion

When blending, part of the apple fruit in the jam recipe was replaced with an equivalent amount of strawberries in the amount of 10 and 20\% of the total volume. A version of jam made only from apple mass was taken as a control.

Were made trial production of apple jam without and with the addition of strawberries. The study of qualitative indicators showed that the dry matter content in the samples is higher than the normalized value of more than 8\% and corresponds to concentrated canned fruits and berries (table 3).

Table 3. Physicochemical indicators of the quality of apple jam with the addition of strawberries.

| Index                        | Apple jam                  | Apple and strawberry jam (10\% berries) | Apple and strawberry jam (20\% berries) |
|------------------------------|----------------------------|----------------------------------------|----------------------------------------|
| Dry matter                   | 69.53±3.48                | 68.81±3.44                            | 68.02±3.41                            |
| Sugars                       | 48.54±2.44                | 47.77±2.40                            | 46.81±2.35                            |
| Organic acids (in terms of malic acid) | 0.31±0.03          | 0.33±0.03                             | 0.45±0.04                             |
| Vitamin C content, mg\% (iodometric method) | 1.2±0.07                | 3.3±0.18                              | 6.7±0.35                              |

According to the analysis, it was found that apple jam, produced without the addition of berry raw materials, had an acidity corresponding to the norm (0.31 and 0.33\%, respectively). With the inclusion of strawberries, the figure increased to 0.45\%, which during storage, possibly, will interfere with the sugaring of the product.

The introduction of strawberries into the apple jam recipe increased the level of vitamin C accumulation in the samples by more than 2.5 times. Vitamin C is a biologically important substance. With the introduction of 10 and 20\% of berry raw materials, the antioxidant content was 3.3 and 6.7 mg / 100 g of jam, respectively. With a physiological daily requirement for vitamin C equal to 90 mg, the finished product satisfies the needs of the human body by 3.7 and 7.4\%.

Organoleptic evaluation of jam samples was also carried out. Each indicator (appearance and consistency, taste and smell, color) was assigned from 1 to 5 points.

The organoleptic assessment of apple jam was 12 points, replacing a tenth of the apple mass with strawberries increased the assessment to 13 points, an increase in the share of berry raw materials to 20\% was estimated by tasters for the maximum number of points - 15.

The analysis of the organoleptic properties of the jam samples showed that when strawberries were added 10\%, the taste of the jam was not expressed. The ratio of apples 80\% and apples 20\% contributed to the formation of a pleasant balanced taste, moderately sweet. There were no off-tastes and odors in the studied samples of jam. Appearance and consistency were a smearing mass with jelly properties. The products were characterized by an attractive aroma, dense homogeneous structure.

A thick, jelly-like mass of jam samples held their shape perfectly, had good stickiness, so the jam can be recommended for sandwiching rolls and cakes, as a sauce for pancakes, as a filling for bakery products at public catering establishments.

When analyzing the nutritional value of jam workings, it was found (table 4) that the protein content was 0.3-0.6 g; fat - 0.2-0.3 g; carbohydrates - 51-65 g; calorie content - 214.2-269.5 kcal; concentration of dietary fiber - 1.2-1.7 g.

Thus, the proposed types of apple jam with strawberries corresponded to the normative documentation for regulated indicators and can be recommended for introduction into production.

5. Conclusion

The study of the technological qualities of individual apple varieties of autumn and winter ripening, grown in the Belgorod region, showed the specificity of the varietal characteristics of the culture.
Table 4. Nutritional value of jam samples.

| Index                   | Apple jam          | Apple and strawberry jam (10% berries) | Apple and strawberry jam (20% berries) |
|-------------------------|--------------------|----------------------------------------|----------------------------------------|
| Proteins, g             | 0.3±0.02           | 0.4±0.02                               | 0.6±0.03                               |
| Fat, g                  | 0.2±0.01           | 0.2±0.01                               | 0.3±0.02                               |
| Carbohydrates, g        | 65±3.25            | 58±2.90                                | 51±2.55                                |
| Caloric content, kcal   | 269.5±13.50        | 241.2±12.10                            | 214.2±11.02                            |
| Dietary fiber, g        | 1.2±0.07           | 1.4±0.07                               | 1.7±0.09                               |

Based on the results of the assessment of a set of indicators, it was found that the most promising for processing is the autumn variety Zhigulevskaia of domestic origin.

Jam was developed from the fruits of apple and strawberries, which, based on the results of determining the quality properties, has established itself as a competitive product for healthy nutrition.

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