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CHEMICAL AND TECHNOLOGICAL TESTS OF BEETROOT IN THE DEVELOPMENT OF TECHNOLOGY OF OBTAINING CONCENTRATED JUICE FROM IT

The criteria for choosing roots crops for processing beetroot into concentrated juice were defined. Researches on an assessment of chemical and technological characteristics of the roots of various botanical crops zoned in the Republic of Belarus and their dynamics at various stages of production of the concentrated juice are conducted.

The objects of research were the fresh and stored beetroot, semi-processed and experimental crops produced in laboratory and under industrial conditions. Experimental samples of the concentrated juice were received at the various modes of technological processing of beetroot (temperature, duration, pH): peeling, grinding, pulp blanching, and juice evaporation. In the studied objects the dry solids and sugars weight ratio, acidity and betanin content were defined. Standard methods of the analysis and principles of traceability of measurements were used for investigation.

Beetroot of botanical varietes Bordo and Cylindra was offered for industrial processing for concentrated juice. They contain more than 17.0% of dry solids, more than 0.1% acidity and more than 125 mg/100 g of a betanin, which correspond to the technological requirements to beetroot crops, which is used for canning. Stabe content of betanin in beetroot during its storage in standard conditions (0–1°C) till 6 months was established. Betanin loss in obtained concentrated juice range 35–69%.

Key words: beetroot, botanical crops, technical analysis, chemical analysis, experimental canning, concentrated juice.

Introduction. Production of concentrated juice is one of the most promising directions of development of the canning industry of agriculture in Belarus. Increasing the share of processed material immediately after harvesting can reduce the economic costs and natural losses that occur during a long-term storage. It is necessary to select out of the whole range of the industrially farmed beets in Belarus the crops that make up 60–75 tons production volume per year on average. However, the range of canned products manufactured from it is limited to natural canned, pickled and dried beetroot. At the same time, today's domestic and foreign markets demand concentrated beetroot juice, which is used as a food additive in the production of various kinds of confectionery and fish products.

An important feature of the consumed concentrated juice from beetroot is its intense red color due to the content of betanin. Betanin is a plant pigment found primarily in red beet refers to betacyanins, which in addition to the coloring ability possess high biological activity due to their antioxidant properties [1].

Development and implementation of technology of concentrated beetroot juice at the republican enterprises led to the need for research on selecting the botanical varieties of beet, corresponding to the technological requirements (Table 1) [2], and the most suitable one to produce a finished product with predictable quality characteristics, which is the aim of this work.

Table 1

Technological requirements for varieties of the beetroot intended for processing

Characteristics	Reference characteristics
Root crop form	Round branch-free
Root crop size, cm	6–10
Pulp colour	Uniform deep-red
Content: dry solids, % sugars, % betanin, mg/100 g	 17–18 Not less than 10 Not less than 100

Main part. *Materials and methods*. The research was based on the technique of chemical and technological tests of vegetable raw materials, developed by the All-Russian Research Institute of Canning and Vegetable-drying Industry, including:

– technical analysis of the raw materials (shape, size and color);

– chemical analysis of the raw material (the main characteristics);

– experimental canning (according to the basic technological regimes) [2].

The objects of study were samples of the table beetroots of the varieties Red ball, Bordo, and Cylindra harvested in 2012–2013, grown in the agricultural farms in the Republic of Belarus.

Technical analysis of the raw materials was carried out by visual evaluation of root crops of different varieties of beetroot and comparing their characteristics with the descriptions given in the

reference books [3]. Chemical analysis of the raw materials was carried out by researching the freshly harvested root crops on the following parameters: the mass fraction of dry solids and sugars, total titratable acidity and content of betanin.

To assess the influence of a particular mode of the process on the quality characteristics of root crops (experimental canning) the varieties were selected according to the results of the research in the two previous stages of the analysis, the dynamics of betanin was studied during storage of beet and its processing into juice concentrate.

Storage of the root crop lasted 6 months under controlled conditions (specialized storage) – at a temperature of 0–1°C. Sampling was performed once a month.

Experimental canning was carried out in laboratory and industrial conditions. Stages of experimental studies on the effect of various process conditions (temperature, duration of exposure, and the pH of the sample), the production of concentrated beetroot juice, i.e. peeling, grinding, pulp blanching, and juice evaporation are given in Tables 2–3.

Table 2

Stages of experimental studies on the effect of processing modes of beetroot crops on betanin contents

1. Washing of beet root crops			
2.1. Steam cleaning	2.2. Mechanical cleaning		
3. Beet root grinding (pulp)			
3.1. Pulp stirring	3.2. Pulp stirring + CA* adding	3.3. Pulp stirring	3.4. Pulp stirring + CA* adding
4. Blanching			

* CA – citric acid; citric acid is added up to pH = 4.0–4.2.

A total of 48 freshly harvested root crops and 54 remaining samples, 42 samples of semi-finished products and 12 samples of concentrated juice from beets were studied.

Table 3

Stages of experimental studies on the effect of evaporation temperature on betanin contents in the concentrated juice from the beet roots

1. Washing of the beetroot		
2. Mechanical cleaning		
3. Juice pressing and its filtering		
4. Juice evaporation (up to dry solids content – 36%)		
t = 60°C, τ = 120 min	t = 70°C, τ = 60 min	t = 80°C, τ = 45 min

Methods of measurement used in the work are shown in Table 4.

Table 4

Methods for characteristics determination

Characteristics	Mode of Control
Mass fraction of dry solids contents	Gravimetric – GOST 28561–90 [4], p. 2
Total titrated acidity	Titrimetric – GOST 25555.0–82 [5], p. 4
Mass fraction of sugars	Titrimetric – GOST 8756.13–87 [6], p. 2
Mass fraction of soluble dry solids	Refractometry – GOST 28562–90 [7]
Betanin content	Photometry [8]

Results of the study. Technical characteristics of the studied varieties of the beetroot crops are shown in the Table 5.

Table 5

Technical characteristics of the beetroot vegetables

Variety	Characteristics of the beetroots		
	Colour	Form	Size, cm
Bordo	Deep-red	Round and round-flat	9–11
Boro	Red	Round	8–10
Red ball	Carmine-red	Round	6–10
Cylindra	Deep-red	Cylindric	4–7

According to the data shown in Table 5, it is seen that all the investigated beet varieties meet the requirements to the technical characteristics (colour, shape and size of the root crops) of the raw materials used for canning (Table 1) [2]. In the description of these varieties [3] it is indicated that they are suitable for industrial processing.

The results of the studies of the chemical composition of freshly harvested beet root crops are presented in Table 6.

The experimental data presented in Table 6 indicate that not all of the values obtained for the studied beet indicators correlate to the reference data [1, 9]. Thus, all the samples of freshly harvested beet have (15.4–17.3) higher solids content than the values given in the reference literature [9]. The similar results were obtained for a total titratable acidity, which is not significantly different for all samples and it was in the range 0.10–0.15%, but it was higher than the reference values [9]. However, the sugar content in all the samples (8.2–8.7%) was lower than the indicated one in the reference source [9].

These results confirm the findings of the scientists about the deterioration of the quality characteristics of the plant material grown in recent decades, due to the use of intensive cultivation technologies for beet root crops, which are mainly aimed at increasing productivity [2].

Table 6

Determination results of the chemical characteristics in the samples of freshly harvested beetroots

Characteristics	Factual results of the investigations of the beetroots varieties				Standard	Reference characteristics
	Bordo	Boro	Cylindra	Red ball		
M. f. DS*, %	17.2	15.4	17.3	16.7	17.0–18.0	13.5–14.0
Acidity, %	0.10	0.13	0.15	0.14	–	0.10
M. f. of sugars, %	8.3	8.2	8.5	8.7	≥10.0	9.0
Betanin content, mg/100 g	129	86	189	75	≥100	33–195

* M. f. – mass fraction; DS (hereinafter) – dry solids.

Comparison of the experimental data with the established technological requirements [2] showed that the beetroots of the varieties under study did not meet the standards for sugar content. However, the samples of Bordo and Cylindra contain dry solids (17.2 and 17.3%, respectively) in the range recommended for the varieties of beet for industrial processing.

The results of the betanin contents in the beetroots (75–189 mg/100 g) correlated with the data presented in the scientific literature (33–195 mg/100 g) [1]. The highest levels of this pigment was registered in the Bordo beet variety sample (129 mg/100 g) and the Cylindra beet variety sample (189 mg/100 g) which met the requirements of the present technological requirements (not less than 100 mg/100 g) [2].

Therefore, a comprehensive assessment of the studied characteristics freshly harvested beet roots beet of different varieties (Table 6), and comparison of the data with the requirements to raw materials [2] such as dry solids content and betanin showed that only the beetroots of the Bordo and Cylindra varieties could be selected for the next stage of research, i.e. experimental canning.

The results of the betanin dynamics study in the beetroots Cylindra variety stored for 6 months at a temperature of 0–1°C are shown in Fig. 1.

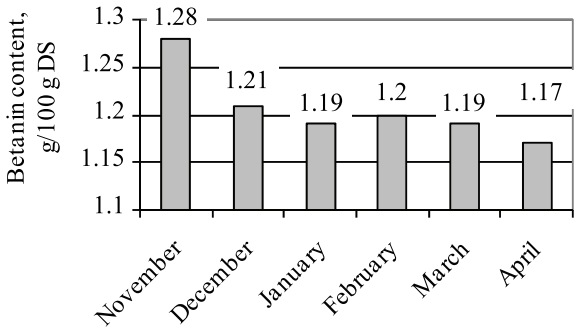

Fig. 1. Changing the betanin content during the storage of Cylindra beetroot variety

As it can be seen from the data in the studied samples of the beetroots during the storage under standard conditions the pigment content remained practically unchanged, the values are in the range 1.5–5.5%.

The results of studies to determine the efficiency of processing conditions on the beet pigment betanin are shown in Fig. 2–3.

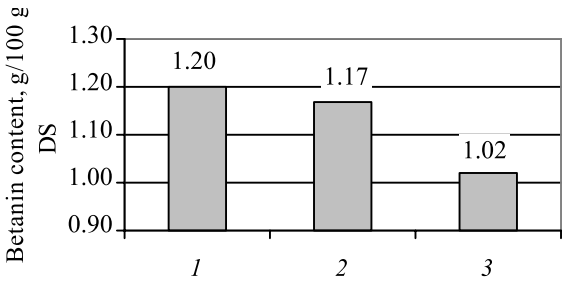

Fig. 2. Change the betanin content in the beetroots in the course of pulp blanching:
1 – fresh beets; *2* – pulp with citric acid, blanched;
3 – blanched pulp without citric acid

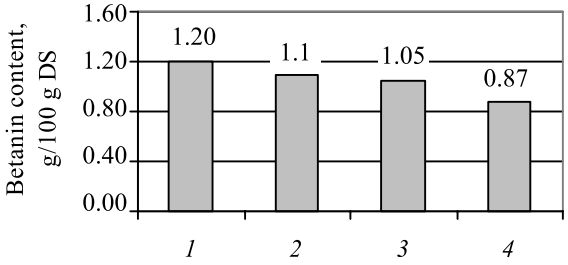

Fig. 3. Change the betanin content in beets at its steam cleaning and blanching pulp:
1 – fresh beets; *2* – beetroots after steam cleaning;
3 – blanched pulp with citric acid;
4 – blanched pulp without citric acid

The experimental data confirm the information in the reference literature concerning the positive effects of citric acid to preserve the betanin in the beet during its processing for canning. Thus, when beet pulp is blanched without addition of citric acid, the pigment loss amounted to 15.0%. However, the prior acidification of the pulp before blanching contributed to its preservation at the same level (Fig. 2).

When the beetroot was cleaned with steam, the betanin content decreased by 9.3% (Fig. 3), and in the course of the further processing, it remained either practically unchanged as in the blanching pulp with citric acid or it significantly reduced (19.2%) when pulp was blanched without additional treatment with citric acid.

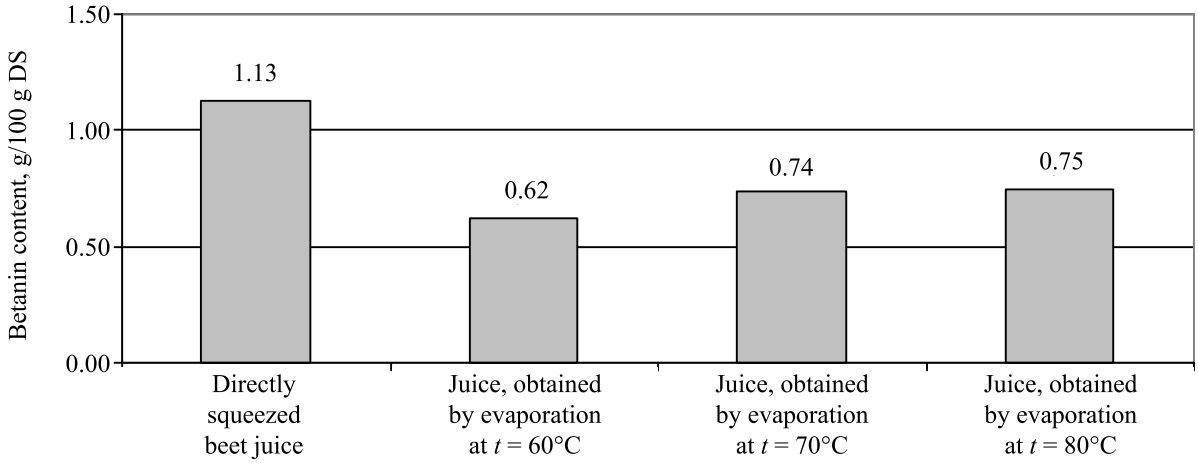

Fig. 4. The betanin content of the concentrated beetroot juice samples (e.g. beetroot Bordo variety) obtained by evaporation method at different temperatures

Thus, the experimental data indicate that the prior reduction of the pH of the beet pulp using edible acids preserve 96.5–97.5% of the basic tested pigment in the raw material after cleaning. Betanin losses in the beet pulp when cooked reach 15.0–20.0% without addition of acids.

The results for the assessment of the betanin losses depending on the evaporation temperature of the concentrated beetroot juice are shown in Fig. 4. The laboratory experiments showed that the temperature increase and the evaporation time decrease (Table 3) result in the betanin losses decrease; they were 45.1, 34.5, and 33.6% for 60, 70, and 80°C respectively.

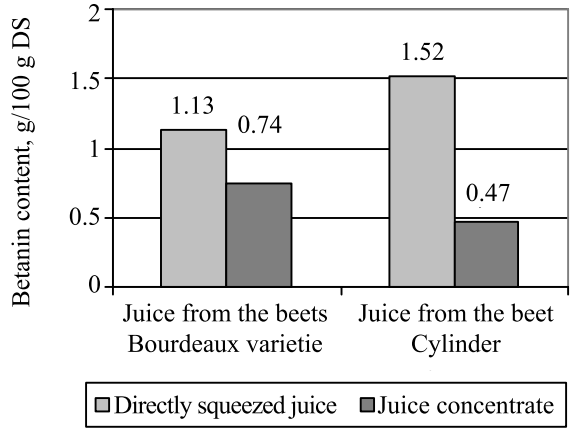

Fig. 5. The betanine content of betaine in the juices directly Spin and concentrated juices

The results of the comparative analysis of the betanin content in the freshly pressed and concentrated juices obtained from the processing of sugar beetroot crops Bordo and Cylindra varieties are shown in Fig. 5.

The data shown in Fig. 5 indicate the loss in the investigated pigment in the samples of the concentrated vegetable juice samples obtained by evaporation method (t = 70°C, τ = 60 min) to 34.5% – during the processing of the Bordo variety, to 69.0% – for Cylindra variety.

Conclusion. The experimental studies of the chemical-technological characteristics of table beetroots, zoned in the Republic of Belarus and their dynamics in the process of storage and processing of raw materials led to the following conclusions:

– it is recommended to use the Bordo and Cylindra beetroot varieties for industrial processing in the juice concentrate, as their freshly harvested beetroots dry solids and betanin content correlate with the technological requirements of the raw material for canning;

– during storage of beetroots under the standard conditions (0–1°C) betanin content did not change from initial one in the raw material;

– betanin loss during the thermal treatment of pulp (15.0–20.0%) can be significantly reduced (up to 2.5–4.2%) by prior treating it with citric acid to achieve pH 4.0–4.2 units;

– the evaporation modes of the juice direct extraction – t = 70°C for 60 minutes and t = 80°C for 45 min was characterized by the equivalent reduction of betanin (34.0%) in the concentrated product;

– the total losses of the investigated pigment in the processing of the beetroot Bordo and Cylindra varieties on the concentrated juice were 34.5 and 69.0%, respectively.

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