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IDENTIFICATION OF THE EFFECT OF RIPENING CONDITIONS ON THE YIELD OF ROSE HIPS AND THEIR PROCESSED PRODUCTS

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Wild rose hip fruit, pulp, beverage, nectar, as well as technological methods and tools are taken as the object of research.

Rose hips have a, bright red color and a rich chemical composition, which makes it a very important raw material for industry. However, insufficient research slows down this work and makes the use of raw materials inefficient. With this in mind, the aim was to study the mechanical and technological characteristics of the femur, which are considered important for industrial processing.

The reflection of ripening conditions on the mechanical, physical and chemical properties of rose hips, as well as the influence of processing methods, especially hot processing, on the quality of the product has been established.

Research has shown that the percentage of fruit cultivation in the Dashkasan region was the lowest, and the highest in the Gadabay region, and the Goygol region took an intermediate position. The Latin hardness of fruits grown in Dashkasan region was 6.41 N. Gadabay region with 5.56 N and Goygol region with 5.47 N. This indicator plays an important role in the storage and processing of fruits. As a result of the treatment, the amount of dry matter in fruit, pulp and beverage increased slightly, titratable acids, ascorbic acid and pH decreased. An increase in total phenolic compounds was observed during the initial heat treatment of the raw material and was noted to be much lower in the pulp and beverage. Hot treatment had a reducing effect on the amount of ascorbic acid, which is considered one of the main components of indicators in the thigh. The obtained results can be used in individual family farms and in the food industry

Keywords: rose hip, fruit pulp, color values, nectar, hydroxymethylfurfural, antioxidant property, ascorbic acid, minerals

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1. Introduction

Negative trends in the health of the population have been observed in the last ten years. So, the average life is getting shorter, common diseases are increasing and so on. It has been known that when the human body produces the energy required to perform its vital functions, millions of compounds called free radicals are formed every second. Environmental pollution, chemical compounds, petrochemical products, industrial waste, medical drugs, ultraviolet rays from the sun, cosmic rays, viruses, infection, stress, cigarette smoke and engine exhaust, and a number of factors constantly increase the number of free radicals. Foods bought from the market, foods with high sugar content, high fat content, alcohol and excess oxygen consumption due to physical exertion cause an increase in the amount of free radicals formed in the body. Free radicals attack cells in the body, subjecting them to oxidation and causing damage. As a result of this oxidation, rapid aging, many diseases and damage to somatic cells can occur in the body. Antioxidant compounds are molecules that react with such free radicals formed in the body and make them inactive and prevent or reduce the effects of a number of diseases such as cancer and cardiovascular diseases. Considering the growing demand for antioxidants in recent years, food manufacturers are trying to meet this need by using artificial antioxidants. Studies show that such antioxidants are not only not effective enough, but can also cause certain side effects (toxicity and by-products). Therefore, plant-based products with antioxidant sources are coming to the fore. In this regard, fresh fruits and vegetables are considered the best natural sources of antioxidants, but some wild-grown fruits far surpass them. One of them is the rosehip fruit, which grows mainly in the foothills and mountainous areas. The amount of vitamin C in rose hips is many times higher than that of blackcurrant, cherry and myrtle. One of the features that makes this fruit superior is that it ripens naturally without requiring special planting and cultivation. Despite all this, in Azerbaijan, the fruit of the rosehip is mainly used at the household level (dried). On the other hand, the mechanical composition and technological characteristics of fruits grown in different regions have not been sufficiently studied and efficient processing methods have not been developed according to the raw materials. Therefore, studying the influence of ripening conditions on the yield of rose hips and products of its processing, as well as the study of the mechanical composition and technological properties of rose hips is relevant.

2. Literature review and problem statement

Rose hips have a rich composition. Various biologically active substances have been found in rose hips, such as polyphenols, flavonoids, carotenoids, ascorbic acid, anthocyanins, tannins and tocopherols [1]. Rose hips also contain various minerals such as potassium, calcium, phosphorus and magnesium [2].

Depending on the growing conditions and the year, the size (size) of the fruits, as well as the composition, also show differences.

In Sicily, rose species grow naturally and in recent years rose hips have been cultivated. Rosa canina L., Rosa sempervirens L., Rosa micrantha Borrer ex Sm are used as ornamental plants. There are no scientific studies on the bioactive compounds of rose hip species grown in Sicily, so studies have been carried out which have shown great variability among four rose species (Rosa canina, R. corymbifera, R. micrantha and R. sempervirens) grown in Sicily (Italy), as in the morphology of rose hips and in the levels of their main bioactive compounds (anthocyanins, polyphenols, carotenoids and vitamin C) and associated antioxidant activity. Fruits collected from Rosa canina and R. corymbifera plants were elongated ellipsoidal or obovate, R. micrantha fruits were hemispherical, and R. sempervirens fruits were spherical. The longest fruits were found in R. canina, R. corymbifera and R. micrantha (average 18.8 mm), while the lowest values were measured in R. sempervirens (11.8 mm). Rose hips collected from R. canina and R. sempervirens showed the highest total polyphenol content (6784.5 and 6241.2 mg GAE/100 g DW, respectively) and the highest antioxidant activity, while rose hips from R. canina and R micrantha showed the highest total anthocyanin content (2.94 and 3.86 mg CGE/100 g DW, respectively). Extended characterization of these wild plants may lead to the discovery of other species or genotypes of southern Mediterranean rose hips as a potential source of bioactive compounds [3].

No previous studies have been conducted on the rosehip ecotypes belonging to R. canina and R. dumalis in Kars province, located in the East Anatolian Region of Turkey. Therefore, some important morphological and biochemical features of fruits and shrubs of ten ecotypes of Rosa canina and ten Rosa dumalis were identified and compared. Ecotypes were found at altitudes of 1446–2210 m above sea level. Fruit weight and fruit pulp ratio ranged from 2.95 g to 4.72 g and 62.55 % to 74.42 %, respectively. Soluble solids (SSC), vitamin C, total phenolic, total flavonoid, total carotenoid and total anthocyanin contents of the ecotypes ranged from 16.9 to 22.7 %, 430–690 mg per 100 g wet weight (fresh weight), 390–532 mg gallic acid equivalent per 100 g fresh weight, 0.88–2.04 mg per g fresh weight, 6.83–15.17 mg per g fresh weight and 3.62–7.81 mg cyanidin-equivalent 3-glucoside per kg, respectively. Fruit weight was quite variable, from 2.95 g (K5, Rosa dumalis) to 4.72 g (K12, Rosa canina) respectively. Total carotenoid content ranged from 6.83 (K9) to 15.17 (K3) mg per g wet weight. Ecotypes R. canina and R. dumalis showed ascorbic acid content from 430 to 690 mg per 100 g of fresh fruit. It turned out that the content of ascorbic acid in rose hips mainly depends on the species and ecotype. As a result, valuable ecotypes of rose hips belonging to R. canina and R. Dumalis were identified among natural rose hip populations, which can be considered for future research on the development of rose hip varieties. In the work on objective features, no research was conducted on the development of new rose hip varieties, since the aim was to determine and compare the morphological and biochemical characteristics of the ecotypes, in connection with their potential use in functional foods [4].

There are studies where environmentally friendly fruits of Rosa villosa L. subsp., were used. mollis (R1), Rosa villosa L. subp. villosa L. (R2), Rosa pimpinellifolia (R3), Rosa iberica (R4), Rosa pisiformis (R5) and Rosa canina (R6) naturally growing in one region. By selecting the same region, detailed information can be obtained on the influence of environmental factors such as altitude, climate conditions and soil properties on vitamin value (vitamins A, E and C), total phenolic content (TPC), flavonoids (TFC) and antioxidant potential. Significant differences were found between species in terms of total flavonoids. The highest value was determined to be 8.04±0.47 mg QE/g in R1, and the lowest value was determined to be 2.92±0.17 mg QE/g in R6. This may be explained as a result of differences in rearing conditions and species-specific differences. Total vitamin C values were determined to be 606.53±0.38 mg/100 ml in R1, 417.06±0.39 mg/100 ml in R6, 415.52±0.31 mg/100 ml in R3, 412.03±069 mg/100 ml in R2, 401.85±0.08 mg/100 ml in R5 and 398.41±0.28 mg/100 ml in R4 group, respectively. The species factor contributes to these data. This study concluded that species diversity may be one of the most determining factors of major compounds and antioxidant potential in plants and the relationships between them. Despite the differences between species, they all have high antioxidant potential and are a source of vitamins [5].

Rose hips are used in the production of marmalade, which have a high content of dry substances, including ascorbic acid, sugars and phenolic compounds [6], yoghurts, seed powders [7], obtained by processing grapes [8], bread with increased antioxidant activity and microbiological stability [9].

Indicators of the mechanical composition of fruits play an important role during their storage and processing. For the first time, the indicators of the mechanical composition of rose hips grown in the Gadabay, Goygol and Dashkasan regions of Azerbaijan were studied: average weight, percentage of fruit pulp, pulp hardness, kernel weight, number of kernels. Color values were measured from the anterior, middle and stem sides of fruits depending on the harvest period.

At the same time, the effect of heat plays a fundamental role in many of the products obtained from rose hips. Ascorbic acid and other compounds, which are very sensitive to heat treatment, are subject to extremely high losses when processed by conventional methods. It should also be noted that even during the application of advanced technologies, in cases of improper adjustment of the hot working mode, significant losses in the quality of the product are produced. Therefore, it is important to investigation the effect of different hot treatments and technological methods on the quality of hips. Because vitamin C is quickly destroyed by heat during cooking, it is possible to use a moderate temperature setting.

3. The aim and objectives of the study

The aim of the study is to identify the influence of ripening conditions on the composition and quality of the semi-finished products obtained from rose hips. This will allow to identify the conditions of heat treatment of rose hips during its processing, which can preserve the originality of the raw material to a greater extent.

To achieve this aim, the following objectives are accomplished:

– to study the mechanical properties of fruits;

– to study physical and chemical properties of fruits;

– to investigate the influence of processing method on semi-finished products.

4. Materials and methods of research

The object of research is wild rosehip fruit, juice, as well as processing methods and tools. The rapidly growing world population's need for food is increasing day by day, which requires more efficient use of available resources. The production of various products from wild rose hips can play an important role in solving this problem.

In the research process, the mechanical and physico-chemical properties of wild rosehip fruit grown in different regions, as well as the effect of hot processing on the composition and quality of raw materials and semi-finished, are comparatively evaluated. The initial hot processing of raw materials and the mode of further processing affected the quality indicators, especially the amount of ascorbic acid.

As a research material, the fruits of the rose hips grown in Dashkasan, Goygol and Gadabay districts of Azerbaijan. Dashkasan district is located at an altitude of 1600–1800 meters above sea level. The surface of Dashkasan, located in the north-east of the Lesser Caucasus, is surrounded by mountains descending to the north. Goygol district is located in the mountainous and foothill zone in the west of the Republic of Azerbaijan, the highest point is 3724 meters above sea level. Separate or mixed forests are formed on the slopes of the fragmented mountain relief in different directions. Gedabak district is located in the middle and high mountain belt of the Lesser Caucasus. Dense and sparse meadows and broad-leaved forests are common in the middle mountains. The altitude of the area is 1480.5 m above sea level, the climatic conditions are varied.

Harvesting begins in the second and third weeks of August and continues until the first week of October.

During the studies, the following measurements and analyzes are performed:

– the weight of the fruit, q – 20 randomly selected fruits are collected in each collection and each repetition and weighed individually with an accuracy of one hundredth;

– the amount of fruit pulp, % – after removing the cores and flower tips of all the fruits whose mass is determined, the remaining pulp part is weighed with an accuracy of one percent and the amount is calculated in % according to the mass of the fruit;

– the firmness of the fruit pulp, N – is determined by immersing a needle with a physical tester (ZVICK Z 0.5) from 2 of 10 randomly selected fruits in each harvest and each replicate. The needle tip of the instrument used to determine the hardness of the fruit blade is adjusted to a depth of 2–3 mm;

– core mass, g/fruit – core mass of 20 randomly selected fruits in each harvest and each replicate was determined by weighing with an accuracy of 0.01;

– number of cores, number/fruit – determined by counting the kernels of 20 randomly selected fruits in each collection and each replicate;

– fruit color (L, a, b) – the color of 5-5 randomly selected fruits in each collection and each replicate was determined with a colorimeter (Minolta CO, Moden CR-400, Japan). Measurements were made between the front (sun exposed part) and back side (non-sun exposed) of fruits, and fruit color values (L, a and b) were determined. L – indicates changes in color brightness. As the L value approaches 100, it reaches its maximum value, and this color is based on 100 % reflection of light directed to white. a-value indicates a color change from green to red and b-value from yellow to blue. Negative values of b are blue, positive values are yellow; Positive values of a mean red color and negative values mean green. Negative or positive values at increasing levels mean that the color becomes darker;

– water-soluble dry matter, % – 5 g of fruit sample is homogenized with a hand blender in 50 ml of distilled water. The amount of dry matter is calculated by the following formula:

$$QM,\% = \frac{B*V}{M}, \quad (1)$$

where B – Brix index in diluted sample, %;

V – the volume in which the sample is concentrated, ml;

M – mass of the sample, g;

– determination of pH indicator – 5 g of fruit sample is homogenized with a hand blender in 50 ml of distilled water, then it is placed in the glass of the pH-meter and determined by measurement;

– the amount of titratable acids, % – 20 ml of the homogenous mass obtained after homogenizing a 5 g fruit sample in 50 ml of distilled water with a hand blender is taken and titrated by adding 0.1 N sodium hydroxide solution until pH 8.1 is reached. Based on the amount of alkali used for titration, the amount of acids that are titrated by converting to citric acid is determined in %;

– the total amount of dry matter, % – determined by the wet weight of 5–5 randomly selected fruits in each collection and each repetition. then those samples are dried in a drying cabinet at 50 °C until they reach a constant mass, and the amount of the obtained dry mass is calculated in % of the wet mass;

– vitamin C, ml/100 g – determined by spectrophotometric method. A 5 g fruit sample is homogenized in 50 ml distilled water. 10 ml of these samples are taken and spun in a centrifuge with 4000 revolutions for 5 minutes. At this time, a sample is taken from the supernatant layer remaining on top for analysis. 100 µl of this prepared extract is taken and 400 µl of oxalic acid, 4.5 µl of 2,6-dichlorophenolindophenol solution are added to it. The mixture is read in a spectrophotometer at a wavelength of 520 nµ. There is an inverse correlation between the amount of ascorbic acid in the extract and the absorbance reading. The amount of ascorbic acid in the fruit is calculated by constructing a calibration graph. Ascorbic acid solution of different concentrations is used to prepare the calibration graph.

Statistical analysis of the received information. Experiments were set up with 3 replicates and 20 fruits were taken in each replicate. The obtained data were analyzed in the SSPS 15 statistical program. In the analysis of variance between trials, the difference between the mean values was determined by Duncan's multiple comparison test.

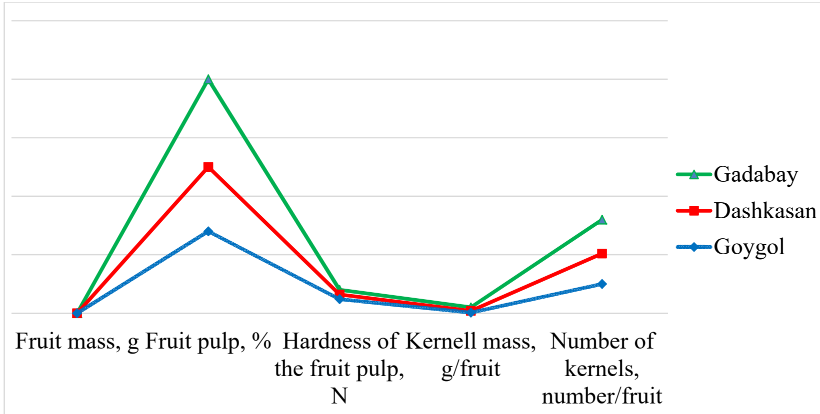

Fig. 1. Mechanical composition indicators of rosehip fruit

5. Research results of the effect of ripening conditions on the composition of rose hip fruit and processed products

5. 1. Study of mechanical properties of fruits

Ripe rose hip fruits collected from different regions were comparatively analyzed. First of all, the analysis of the mechanical composition of the fruits was performed. The results of the analysis conducted according to the methodology are given below (Fig. 1).

It was found that the average mass of ripe rose hips in Goygol region was 2.99 g, in Dashkasan region it was 2.83 g and in Gadabay region it was slightly higher, that is, 3.42 g. The amount of fruit lateness as a percentage was observed the least in the fruits grown in Dashkasan district, the most in Gadabay district, and at this time Goygol district took an intermediate position. It is possible to take into account the hardness of the fruit pulp as one of the factors that play a role in the processing process. It is known that this indicator has a decisive role in product storage. As it can be seen, the fruits grown in Dashkasan district were in a better position in this regard and the hardness of the fruit was 6.41 N. After that came Gadabay district with 5.56 N and finally Goygol district with 5.47 N. This indicator is intended for the future storage and processing of the product.

The mass of rosehip seed was 1.03 g/fruit in Goygol district, 0.87 g/fruit in Dashkasan district and 0.95 g/fruit in Gadabay district. The number of locusts was the highest in Dashkasan district with 29.25 units/fruit, the least in Goygol district with 27.87 units/fruit, and the average amount in Gadabay district with 28.63.

During the conducted analyses, the difference between the average indicators was legitimate by making $p<0.05$.

Color values were measured in fruits in the collection variable. Measurements were made from the front, middle and stem side of the fruit (Fig. 2–4).

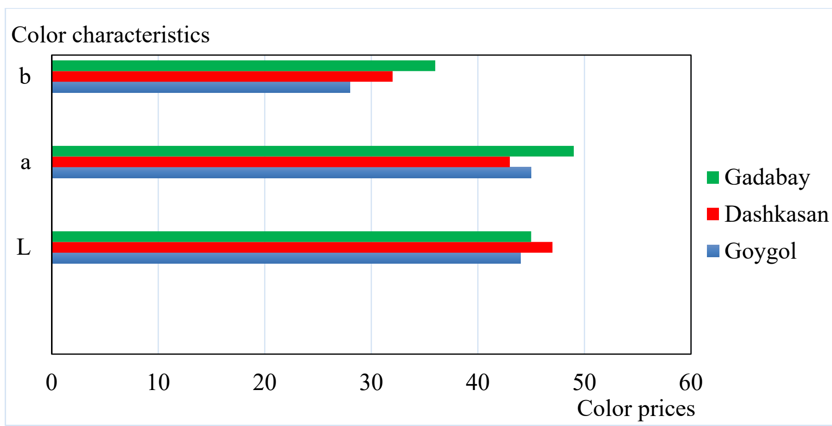

Fig. 2. Color values from the front of the fruits: L – brightness measurement value; *a* – redness level; *b* – level of change from blue to yellow

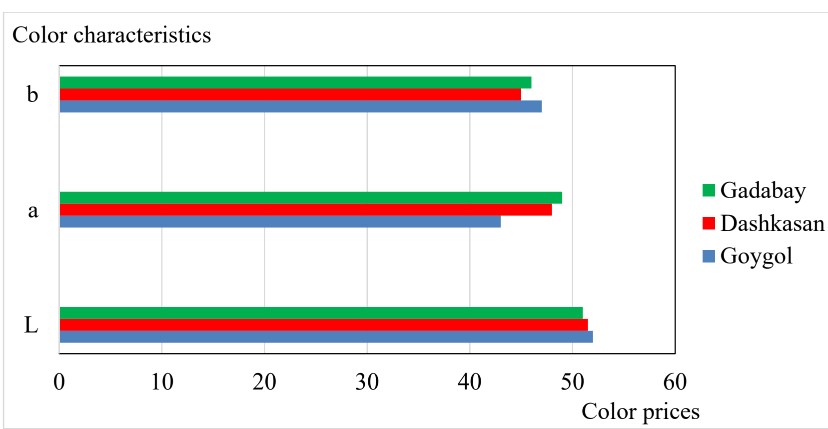

Fig. 3. Color values from the back of fruits: L – brightness measurement value; *a* – redness level; *b* – level of change from blue to yellow

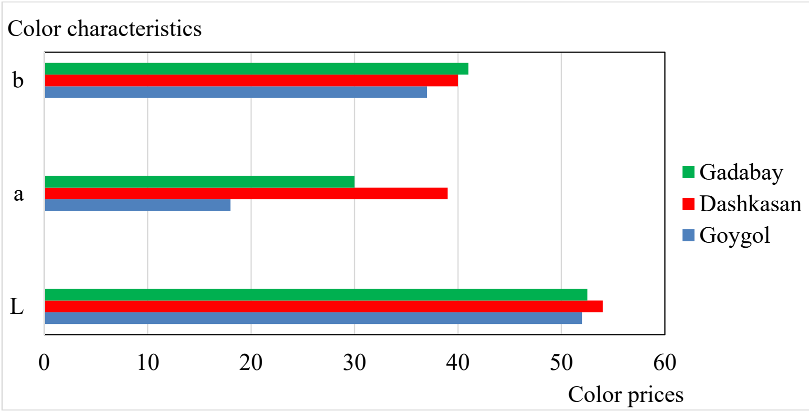

Fig. 4. Color values of fruits from the stalk side: L — brightness measurement value; *a* — redness level; *b* — level of change from blue to yellow

As it can be seen, the *L*-brightness index fluctuated between 44.36–46.51 on the front side of the fruit, and at this time, the fruits grown in Dashkasan district were in front, those from Goygol Yaron were at the end, and Gadabay district was in an intermediate position.

It is worth noting that the value of *a* (+red, –green) and more precisely redness is high in fruits grown in Gadabay region, both on the front and back of the fruit. This indicator was 49.31 and 49.60 respectively. *b* value (+yellow, –blue) was higher from the front side of the fruit in Gadabay district (35.60), from the back side of the fruit in Goygol district (48.62) and from the stalk side of the fruit in Gadabay (41.63). Since these values reflect the yellow color, it shows that the first one is dominant in this part, not blue. During the measurements, the difference between the mean values ($p<0.05$) changed in the interval satisfying the confidence level.

5. 2. Study of physico-chemical properties of fruits

Physico-chemical composition indicators of rose hips grown in different regions were studied. The results obtained are given below (Table 1):

Table 1

Physico-chemical composition indicators of fruits

Indicators	Regions		
	Goygol	Dashkasan	Gadabay
Water-soluble solids, % (WSS)	26.11	28.45	25.33
pH	3.43	3.34	3.61
Vibrating acidity, %	2.86	3.21	2.69
The total amount of dry matter, (TADM), %	53.94	55.15	53.26
Carbohydrates, %:	12.4	13.3	11.95
Total sugar	11.2	12.1	10.46
Invert sugar	1.3	1.2	1.2
Sucrose	2.73	2.30	2.35
Cellulose	846.91	605.84	962.73
Total phenolic compounds, mg GAE/100 g	8.09	9.36	15.20
∝ – Tocopherol (vitamin E), mg/100 g	2.31	1.96	2.86
P – carotene (vitamin A), mg/g	9.01	9.0	9.2

The total amount of dry matter was the highest in Dashkasan district and was 55.15 %. Although the dry matter in the fruits collected from Goygol and Gadabay regions is close to each other, Goygol region has a slight advantage. According to the amount of total phenolic compounds, tocopherols and p-carotene, rose hip fruits collected from Gadabay district had a better position. Although the amount of alpha-tocopherol in Dashkasan region is higher than that of Goygol region, the amount of total phenol compounds and p-carotene is lower than that of Goygol region.

During the research, the vitamin content of rose hip fruits grown under natural conditions in the regions was analyzed (Table 2):

Table 2

Amount of vitamins in rose hip fruit samples

Vitamins mg/100 g	Regions		
	Goygol	Dashkasan	Gadabay
Vitamin C	4630	4740	4590
Vitamin P	2130	2100	2215
Vitamin K	0.034	0.029	0.041
Vitamin B_1	121	120	120.5
Vitamin B_2	7.03	7.01	7.04
Carotene	3.80	3.81	3.80

As it can be seen, the rose hip fruit was richer in vitamin C and this indicator varied between 4590–4740 mg/100 g by region. The amount of vitamin P, second only to vitamin C, fluctuated between 2100–2215 mg/100 g. Among other vitamins, vitamin B_1, which is notable for its quantity, was between 120–121 mg/100 g in fruits depending on the conditions of cultivation, but vitamins K, carotene and B_2 were between 0.029–7.04 mg/100 g.

The amount of mineral substances in the rosehip fruit samples also changed in different intervals (Table 3):

Table 3

Amount of mineral substances in rose hip fruit samples

Content indicators	Regions		
	Goygol	Dashkasan	Gadabay
Ash, %	2.1	2.2	2.0
Calcium	186.5	173.4	182.7
Phosphorus	2215	2346	2184
Potassium	3700	4100	4170
Sodium	16.0	16.5	16.9
Magnesium	153	151	152
Manganese	870	882	880
Iron	20.3	21.4	21.7
Copper	3.30	3.20	3.25
Zinc	1.81	1.90	1.87

Apparently, the mineral elements found in the fruit samples are all important for human nutrition. The amount of calcium was the highest in Goygol, the least in Dashkasan district, the amount of phosphorus was highest in Dashkasan district, and potassium was observed in Gadabay.

Heavy metals (arsenic, cadmium, lead and mercury) and pesticide residues that can harm human health are not found here. All this indicates the possibility of using hips for all groups of people, including childrens food.

5. 3. Effect of processing method on product quality

Hips, which have a very high nutritional value, are considered as a product with more vitamin C. The phenolic compounds and ascorbic acid contained in it determine its high antioxidant properties. In today's conditions, where the demand for organic products related to healthy nutrition is increasing day by day, consumers prefer products that are obtained naturally and do not have additives. A clear example of this is the growing demand for such products made by primitive methods at home. It is important to investigate the changes in nutritional value and antioxidant capacity during the processing of rose hips into beverage and other products.

The effect of pre-heat treatment on raw material, pulp and beverage content during the extraction of beverage from the fruit of the rose hip was studied. One of the main indicators affecting the quality of the hip is the amount of dry matter in it [10, 11]. At the same time, the specific role of water-soluble solids (Brix index), titratable acids, formalin number, ascorbic acid, total phenolic compounds and others should be noted (Table 4).

As it can be seen, rose hips were analyzed without prior heat treatment (control) or with heat treatment (experiment). At the same time, samples of pulp and beverage obtained from non-hot-processed and pre-hot-processed raw materials were also analyzed. It was found that during hot processing, there was a slight increase in the amount of dry matter in raw materials, pulp and beverage. Corresponding decreases in titratable acids, ascorbic acid, and pH were observed. Although the amount of total phenolic compounds during hot processing was noticeable with a significant increase in the raw material, this increase in the pulp and beverage was noted for being weak. Heat treatment had a reducing effect on the amount of ascorbic acid, one of the main constituent indicators. This was especially noticeable in the process of extracting raw materials and then in the process of extracting beverage, as in the experimental options. If the amount of ascorbic acid in the first raw material that was not hot-processed was 751.36 mg/100 g, this amount was 116.43 mg/kg in the obtained beverage. As can be seen, there was a 6.45-fold decrease in the amount of ascorbic acid.

One of the main criteria used during quality control of fruit drinks is formalin number. Formol number in fruit beverages is an indicator that reflects the amount of total amino acids it has. As it can be seen, the number of formalin has undergone certain changes during the development and at different stages of product acquisition. A decrease in formalin number of hot-processed raw materials and crushed was observed. The largest reduction was observed in beverage samples compared to raw materials. So, if the formalin number varied between 9.6–10.0 in the raw material, this indicator was between 5.3–6.1 in the beverage.

The estimated TPC in fruits is 6021.6 mg GAE/100 g (Table 4). This coincides with the data obtained for Lithuanian rosehip (for example, 5013±417 mg GAE/100 g in R. pimpinellifolia) [12] and rosehip R. canina grown in Turkey (6298±117 mg GAE/100 g) [13].

The effect of preliminary heat treatment on the quality of the obtained samples was studied. For this purpose, the amount of total sugars, including sucrose, was determined. In addition, the amount of hydroxymethylfurfural (HMF), which is the main quality indicator, and color indicators (*I*, *a* and *b*) were determined (Table 5).

Table 5

Effect of heat treatment on physico-chemical composition indicators

Variants		Content indicators					
		Total sugar, %	Sucrose, g/100g	HMF, mg/kg	Color values		
					L	a	B
Raw material	Primary	12.76	3.23	1.09	24.98	25.14	11.01
	Hot worked	9.85	0.57	6.65	26.11	25.39	11.52
Squashed	Primary	8.96	1.26	9.86	27.0	19.1	11.67
	Hot worked	7.40	1.04	16.73	26.4	19.35	11.84
Beverage	Primary	5.10	1.86	21.07	26.7	18.63	14.72
	Hot worked	5.20	1.48	28.86	26.5	18.77	14.86

While the amount of total sugars in unheated hip raw materials was 12.76 %, including sucrose 3.23 g/100 g, after hot processing these indicators were 9.85 and 0.57, respectively. A 1.89–2.50 times decrease in the amount of total sugars in the beverage was observed compared to the raw material. Hot working resulted in increased HMF content. This increase was 6.1 times in hot-processed raw materials, 1.69 times in hot-processed mash and 1.36 times in beverage.

HMF is not found naturally in fruits and fruit beverages. The occurrence of small amounts of HMF in raw materials can be attributed to factors of storage origin. The excess amount of HMF in the hot-worked samples is due to the boiling operations in open pots. There were no sharp deviations in color indicators.

Table 4

The effect of initial heat treatment on physical and chemical composition indicators

Variants		Dry matter, %	Water-soluble solids (Brix)	Ash, %	Formol number	pH	Ascorbic acid, mg/100 g	Common phenolic compounds, mg/kg
Raw materials	Primary	38.43	21.46	2.8511	10	3.69	751.36	6021.6
	Hot worked	39.05	19.62	2.0013	9.6	3.65	564.63	7173.4
Squashed	Primary	23.77	13.60	1.9346	10	3.71	311.42	8351.3
	Hot worked	24.35	13.81	1.8521	9.2	3.67	216.77	8432.7
Beverage	Primary	7.61	8.03	1.1791	6.1	3.63	116.43	11250
	Hot worked	8.01	8.34	1.2101	5.3	3.64	94.25	11430

As can be seen from the Table 5, the *L* indicator, which expresses clarity, varied from 24.98 to 27.0 for different options. In this case, the value of *a* was positive, being 18.63–25.39. That is, it was in the direction of redness. *b* value varying between 11.01–14.86 expressed jaundice.

Although the rose hip has a very high amount of vitamin C when it is ripe, its loss begins to increase when it is frozen for storage. At the same time, the hot processing carried out when extracting nectar from it also causes the loss of vitamin C. When products are prepared with the addition of biscuits and sugar, losses are high because the hips are exposed to heat.

Physico-chemical indicators of rose hip nectar samples are given (Table 6).

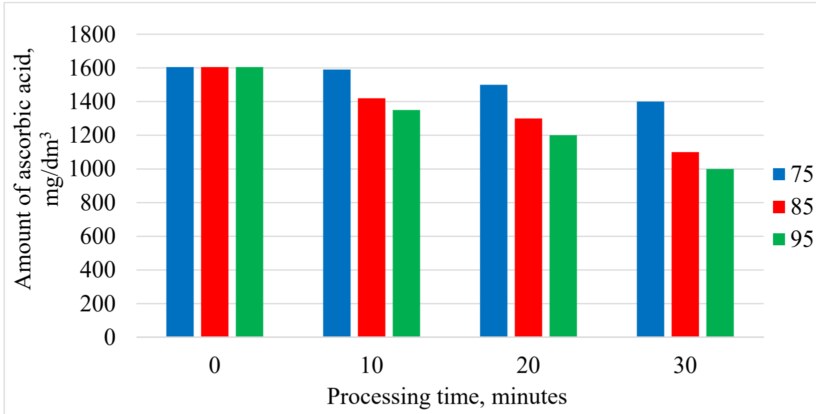

Fig. 5. In the nectar of the hips of hot treatments carried out for different periods of time effect on the amount of ascorbic acid

Table 6

Some physicochemical characteristics of rose hip nectar samples

Content indicators	Variants		
	Goygol	Dashkasan	Gadabay
Dry matter, in %	13.32	13.97	13.88
Ash, in %	0.17	0.19	0.18
pH	3.76	3.82	3.84
Titratable acidity, %	0.34	0.33	0.35
Brix, %	12.31	12.66	12.49
Sugar, %	12.21	12.30	12.20

The amount of ash in rose hip nectar samples varied between 0.17–0.19 %. At this time, the total amount of dry matter is 13.32–13.97 %; brix index was 12.31–12.66 % and sugar was 12.20–12.30 %.

During hot processing of nectar samples at different temperatures and durations, changes in color were noticed (Table 7).

Table 7

Nectar of different duration and temperature application effect on the color of samples

Temperature, C°	Processing time, minutes	Color prices		
		L	*a*	*B*
75	10	14.01	12.46	19.80
	20	13.92	12.60	19.77
	30	13.97	12.53	19.63
85	10	13.46	12.61	19.65
	20	13.29	12.70	19.57
	30	12.99	12.64	19.61
95	10	13.00	12.85	19.50
	20	12.97	12.86	19.61
	30	12.88	13.23	20.03

As it can be seen, under the influence of heat of 75 °C, the values of *L* and a decrease and the value of *b* increases. Although a similar situation was observed during processing at temperatures of 85 and 95 °C, a decrease in the value of *L* was observed at 95 °C.

The effect of heat treatments carried out for certain periods on the amount of ascorbic acid was studied (Fig. 5).

Apparently, the rose hip fruit and its nectar are rich in ascorbic acid. Although the amount of ascorbic acid in the nectar has decreased due to the fruit, it is noticeable that this amount is still quite high (1635 mg/dm^3) in the nectar samples that are not hot-processed. The increase of the hot processing time at 75 °C from 10 to 30 minutes was distinguished by the small loss of ascorbic acid compared to other samples.

Samples with 0 %, 5 %, 10 %, 15 %, 20 %, 25 and 30 % sugar concentration were prepared for the tasting of rosehip beverage samples. At this time, no other substances were added to the fruit beverage except sugar and water. This makes these samples different from the mass-produced ones. Rose hips are mainly used in the production of marmalade. The color points received by those samples during the evaluation are given in the table below (Table 8).

Looking at the indicators for the variants, it is clear that the other samples received almost double and more prices than the color control (sugar-free) variant. Compared to the control, the beverage with 10 % sugar had the highest value (3.25 points), followed by a decrease in the order of samples 4, 5 and 6, and finally, a slight increase compared to them in the 7th sample (2.96 points) was observed.

The taste index of the beverage samples was evaluated in a 10-point system. During the taste evaluation, an increase in price was recorded in the experimental samples compared to the control option. At this time, the 3rd (10 % sugar), 5th (20 % sugar) and 6th (25 % sugar) options were mentioned as samples with the best taste indicators. Option 7 (30 % sugar) was distinguished by having a lower value than the other experimental samples, although it was slightly higher than the control. This option was noticed by receiving 5.36 points during the evaluation.

Evaluation of the prepared beverage samples according to their appearance was carried out with a 4-point system. At this time, the highest price (3.12) was awarded to the 3rd option, that is, the sample with 10 % added sugar. In other options, which involve increasing the concentration of sugar, this indicator was noticed as low.

The smell of the beverage samples was evaluated in a 6-point system. When the beverages were evaluated for their smell, the control variant was evaluated higher than the experimental samples with added sugar, except for variant 6 (25 % sugar). This suggests that the addition of sugar has resulted in odor limitation in many cases.

Table 8

Final degustation of rosehip beverage samples prepared in different concentrations values

No.	Variations	Degustation indicators				Total
		Color (4 points)	Taste (10 points)	View (4 points)	Odour (6 points)	
1th	Control (without sugar)	1.25	4.95	1.27	4.16	11.63
2nd	5 % sugar	2.84	6.65	1.85	3.98	15.32
3rd	10 % sugar	3.25	7.76	3.12	3.91	18.04
4th	15 % sugar	2.65	7.60	2.57	3.87	16.69
5th	20 % sugar	2.36	7.75	2.14	3.81	16.06
6th	25 % sugar	2.15	7.86	2.05	4.24	16.3
7th	30 % sugar	2.96	5.36	2.64	3.56	14.52

From the general results, it can be seen that the 3rd option, i. e., the sample with 10 % sugar added, was distinguished among the experimental samples with a higher value (18.04 points) compared to the control. In the following samples, a tendency towards a decrease in the total price was observed with the increase of sugar.

6. Discussion on the results of the study of the influence of ripening conditions on the composition and quality of the semi-finished products processed from the wild rose hip fruit

Wild rose hip fruits were collected and studied in different regions such as Goygol, Dashkasan and Gadabay. The individual mass of 20 randomly selected fruits in each harvest was determined, then the average mass of fruits, the amount of fruit pulp in %, pulp hardness, kernel mass, kernel number, fruit color values and physico-chemical composition indicators were determined and compared. It is known that the total amount of dry matter, carbohydrates, sugars, vitamin content and mineral content of fruits have different values in different regions. Then the effect of the processing method on the quality of the semi-finished product was studied. The effect of pre-heat treatment on the composition of raw materials, pulp and juice was studied. The amount of ascorbic acid in the juice has decreased several times compared to the first raw material that has not been heat processed. A similar situation was observed regarding the formula number. An increase in the amount of hydroxymethylfurfural (HMF) occurred during heat treatment. Hot processing was also observed with changes in color indicators.

When the rose hips were kept frozen and also when nectar was extracted from it, there were losses in the amount of vitamin C in all 3 regions compared to the original raw material. During nectar extraction, heat treatment at 75 °C, 85 °C and 95 °C for 10–30 minutes was applied. It was found that effective protection of ascorbic acid was possible by extending the time of hot processing from 10 to 30 minutes at a lower temperature.

The juice samples obtained from the rose hips were tasted without adding sugar and with 5.0–30.0 % added sugar. During the organoleptic analysis, the sample of juice prepared by adding 10 % sugar was considered more rational.

The average mass of fruits, the hardness of the fruit blade, the mass of the kernel received different values in different regions. The average mass of the fruit was higher in Gadabay district, Latin firmness in Dashkasan district, kernel mass in Goygol district, number of kernels in Dashkasan district compared to others. The different mechanical composition of the fruits can be associated with the soil and climate conditions of those regions. Thus, Gadabay region is characterized by denser forest cover and humid weather, Dashkasan region is characterized by relatively weak forest cover and bare slopes. From this point of view, Goygol district is distinguished by its middle position. The fact that the fruits are large in Gadabay region, the percentage of fruit pulp is high, and the firmness of the pulp in Dashkasan district can be related to this (Fig. 1).

The color values of the fruits at the time of harvest maturity were determined. Measurements were performed on the front, middle and stem side of the fruit. On the front side of the fruits, the values of a and b are higher in Gadabay region, and the value of *L* is higher in Dashkasan region (Fig. 2); color values from the back side of fruits – *L* and *b* values are higher in Goygol region, a value is higher in Gadabay region (Fig. 3), on the other hand, the prices of *a* and *L* were higher in Dashkasan district, and the price of *b* was higher in Gadabay district (Fig. 4).

Physico-chemical composition indicators of rose hips grown in different regions were studied. The amount of dry matter is the highest (55.15 %) in Dashkasan district; the amount of total phenolic compounds, tocopherols and p-carotene was higher in Gadabay region (Table 1).

During the study of the vitamin content, it was determined that the amount of vitamin C was relatively high in fruits grown in Dashkasan district, vitamin P in Gadabay district, and vitamin B_1 in Goygol district (Table 2).

The amount of ash in the samples varied between 2.0–2.2 %. At that time, according to the quantity of metals, K was higher, followed by Mn, Ca, Mg, Fe, Na. A higher amount of phosphorus was found in Dashkasan region. The amount of calcium was observed the most in Goygol and the least in Dashkasan district (Table 3).

The effect of pre-heat treatment on the composition of raw materials, pulp and beverage obtained from it was studied. It was found that during hot processing, a slight increase in the amount of dry matter, titratable acids, ascorbic acid and a decrease in the pH index were observed. If the amount of ascorbic acid in the first raw material that was not hot-processed was 751.36 mg/100 g, this amount in the beverage was 116.43 mg/kg, that is, there was 6.45 times decrease (Table 4).

The effect of preliminary heat treatment on the quality of the obtained samples was studied. Due to the raw material, there was a decrease in the amount of total sugars in the beverage, and an increase in the amount of hydroxymethylfurfural (HMF). The value of *L*, which means clarity, is between 24.68–27.00. The *a* value varied from 18.63 to 25.39, and the *b* value from 11.01 to 14.86. The decrease in the amount of sugars during hot processing can be explained by their entering various reactions (including carbonylamine reaction) and partial caramelization. One of the main products formed during hot working is HMF. The initial hot processing of raw materials prevents the high growth of these types of substances in the future processing product to a certain extent (Table 5).

Hot processing during the preparation of nectar from rose hips was accompanied by a loss of dry matter in the composition (Table 6) and also a change in color values (Table 7).

The hot-processed samples were characterized by losses in the amount of vitamin C compared to the control. However, increasing the time of hot processing at a relatively low temperature ensured better preservation of the amount of vitamin C compared to the short-term high temperature (Fig. 5).

The samples of rosehip beverage were organoleptically analyzed without adding sugar (control), with 5, 10, 15, 20, 25 and 30 % sugar added. Compared to the control, the third option, i. e., the sample enriched with 10 % sugar, stood out among the experimental samples. A decrease in tasting value was observed in subsequent samples with the increase of sugar. As the dose of sugar added to the juice increases, its organoleptic indicators decrease can be explained by the fact that the juice tastes too sweet and deviates more from its natural quality indicators (Table 8).

The disadvantage of the method is the decrease in the amount of ascorbic acid and the increase in the amount of HMF in continuous hot processing.

Similar results were observed in a study of the effects of convective drying (50–80 °C) and air flow (0.5–1.5 m/s) on the content of phenolic acids, flavonoids and anthocyanins, texture and microstructure of dried black rose hips [14].

Losses of ascorbic acid are observed during short-term treatment at high temperatures. The difference between our method is that the initial hot processing is carried out at a minimum temperature and for a long time.

Due to the changes in caramelization, color and taste, its application for juice production in large production conditions is limited, and the theoretical solution should be taken into account in future work.

The research requires the study of the hip fruit in the direction of other processed products and the development of processing methods and tools that can preserve the originality of the raw material more.

7. Conclusions

1. The average mass of ripe rose hip fruits in Goygol region was 2.99 g, in Dashkasan region it was 2.83 g and in Gadabay region it was slightly higher, i. e. 3.42 g. The amount of fruit pulp in percentage was the least in the fruits grown in Dashkasan district, the most was observed in Gadabay district, and at this time Goygol district took an intermediate position. In Dashkasan district, the hardness of the bed is 6.41 N. After that came Gadabay district with 5.56 N and finally Goygol district with 5.47 N.

2. The total amount of dry matter in Dashkasan region was higher than others – 55.15 %. Gadabay region had a superior position in terms of total phenolic compounds, tocopherols and p-carotene. Although the amount of alpha-tocopherol in Dashkasan region is higher than that of Goygol region, the amount of total phenol compounds and p-carotene is lower than that of Goygol region. Vitamin C was higher in Gadabay district with 501.33 mg/100 g, average in Dashkasan district with 465.11 mg/100 g, and relatively low in Goygol district with 398.22 mg/100 g.

3. While the amount of total sugars in unprocessed hip raw materials was 12.76 %, including sucrose 3.23 g/100 g, after heat processing, these indicators were 9.85 and 0.57, respectively. A 1.89–2.50 times decrease in the amount of total sugars in the beverage was observed compared to the raw material. Hot working resulted in increased HMF content. This increase was 6.1 times in hot-processed raw materials, 1.69 times in crushed and 1.36 times in beverage. During the organoleptic analysis of the hip beverage samples prepared without added sugar (control), as well as with the addition of 5, 10, 15, 20, 25 and 30 % sugar, variant 3 with a higher value (18.04 points), i. e., 10 % added sugar. The sample is different. The subsequent increase in sugar was accompanied by a decrease in the overall value.

Conflict of interest

The authors declare that they have no conflict of interest in relation to this research, whether financial, personal, authorship or otherwise, that could affect the research and its results presented in this paper.

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Data availability

Data will be made available on reasonable request.

Use of artificial intelligence

The authors confirm that they did not use artificial intelligence technologies when creating the current work.

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