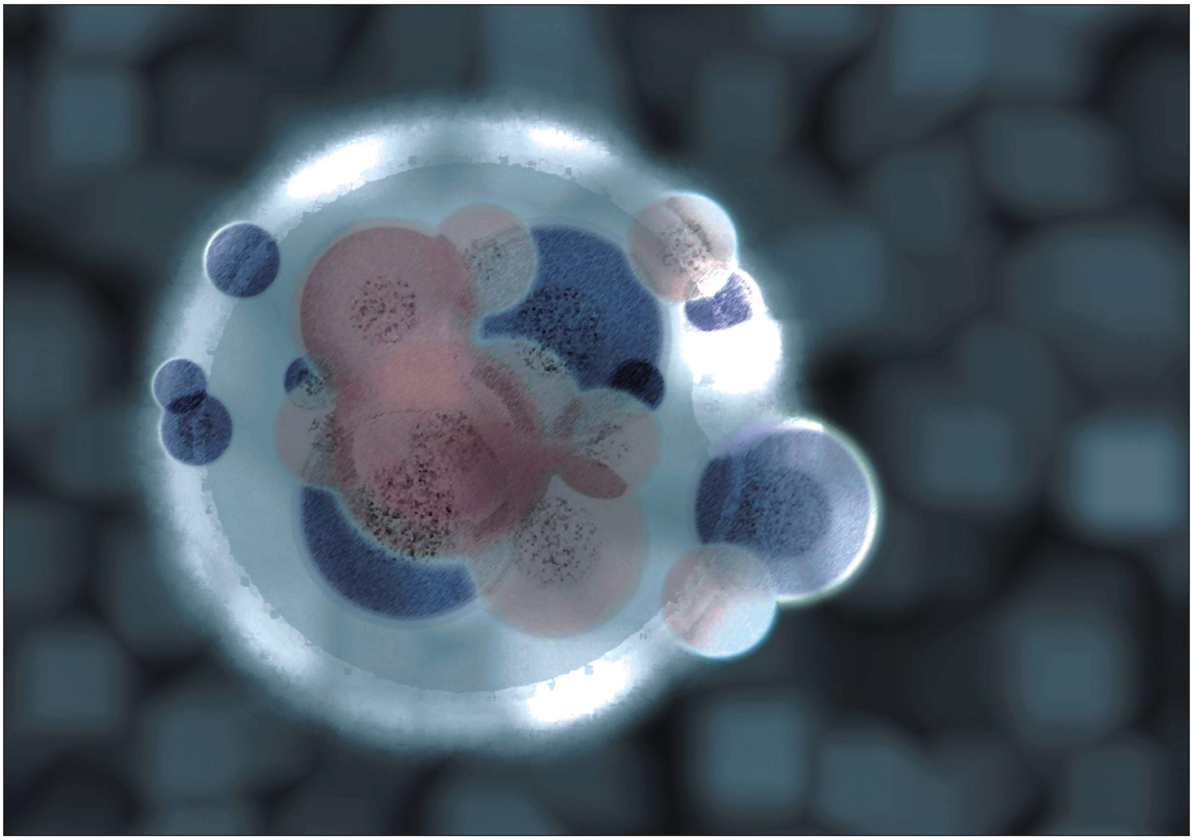

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Research Article
Improving the Biotechnology of Pomegranate Botanical Extracts, Taking into Account the Need to Deepen the Processing of Raw Materials

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Abstract
Background and Objectives: The POMx and Pomanox extract technologies have been developed and used in the production by Pom Wonderful and Probeltibio companies. The production of pomegranate extracts was studied due to their beneficial effects on human health. The purpose of this study was to make better use of the functionality of Pomanox extract technology and to combine the extraction processes of both groups of polyphenols in one technology. **Materials and Methods:** POMx polyphenols were isolated by means of enzymatic water treatment of pomegranate juice by-products at temperature of 37-71°C. Pomanox technology is designed for enzymatic water treatment of whole pomegranate fruits, while its function is mainly to extract and use only the juice polyphenols at temperature of 4-30°C. After its implementation solid residue left behind which can be used for the preparation of POMx polyphenols. Experiments were conducted with grinding and enzymatic water extraction of fruits of the Azerbaijan pomegranate variety in the framework of the modes of industrially applied technologies. **Results:** It was found that the treatment of the solid residue at 71°C makes it possible to extract 32% more polyphenols in the extract than in a single extraction at 20°C. **Conclusion:** It is advisable to combine the processes of extraction of polyphenols of juice and peel in one technology which was not originally part of the function of this technology.

Key words: Pomegranate extracts, manufacturing technologies, underutilized potential, functional expansion

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

The growing demand for botanical preparations and environment friendly methods of their production has stimulated the search for new sources of biologically active substances and the development of effective methods for their extraction, purification and identification. Researchers are particularly interested in the phytocomplex of pomegranate fruits[1-4].

Usually, in the preparation of polyphenols, the rind remaining after obtaining the juice from the pomegranate fruit is used[5-7]. Usually, the peel is used in dried form and studies have also been conducted to obtain polyphenolic antioxidants directly from raw (fresh) by-products left after receiving pomegranate juice[8]. The peel of pomegranate fruits at a temperature of 0°C can maintain its quality for 21 days, at 2°C up to 18 days and at 5°C up to 14 days[9].

At the time, some developments received positive feedback from managers in the field of technological innovation, which played a positive role in their integration into the industry.

At one time, a well-known manufacturer of pomegranate juice and extracts, Pom Wonderful, served as the patent holder of one of these developments[10]. It receives polyphenols with POMx brand from by-products of pomegranate juice production. Their extraction is carried out with water and the participation of the enzyme at 43-71°C.

The technology of the Spanish company Probeltibio for obtaining an extract called Pomanox is based on the enzymatic extraction of whole pomegranate fruits using purified water at 4-30°C. This relatively mild temperature allows to extract mainly only the polyphenols of the juice from the fruit.

The polyphenols of Pom Wonderful (POMx, one 1000 mg capsule contains 753 mg of polyphenols) and Probeltibio (Pomanox, one 200 mg capsule contains 64-100 mg of polyphenols) are now well-deserved popularity on the market of pomegranate polyphenols.

The POMx technologies are credited with a flaw such as obtaining a target product that does not contain certain phytochemicals (smaller ellagitannins, anthocyanins, etc.) that are characteristic only for the juice fraction. The method in the proposed version generates not only sugars but also several other substances such as organic acids. Presence of organic acid in the treatment of this extract can cause side effects and therefore undesirable.

These disadvantages were avoided by the developers of the Pomanox pomegranate extract technology under the EP 1967079 patent[11], which is now owned by the Spanish firm Probeltibio. The peculiarity of this development is that it provides the production of phenols in pure form. The significant health benefits of this extract are also indicated by recent studies[12] up to 2018.

These two industrially applied technologies can be considered as related inventions, they can still be cons, given that each of them is extracted at atmospheric pressure by finely grinding the source material with the addition of water. However, there is one discrepancy between them. At first glance, it is small and concerns the applied temperature regimes (in one of these technologies, this mode is "gentle" and does not go beyond 4-30°C, in the other it is much tougher and is accepted as 43-71°C). But the temperature of extraction acts in this case as the basic factor that actually determines how fully you will be able to realize the potential of technology, one of which is designed conceptually to extract and use mostly soluble phenols fruit peel and the other the juice of the fruit. At the same time, it is the extraction temperature that really determines how much new waste in the form of a water-insoluble solid residue each of these technologies will leave behind.

Therefore, the extraction temperature was in the field of interest. This study find out its role in achieving an acceptable level of quantitative extraction of water-soluble phenols from crushed whole pomegranate fruit.

MATERIALS AND METHODS

The study was carried out in July, 2018-January, 2020 in the laboratory of fruit storage and processing technologies of the Research Institute of Fruit growing and Tea-growing of the Ministry of Agriculture of the Republic of Azerbaijan.

Objects of research and used materials and chemicals: The study included fruit varieties of folk selection Kyrmyz-Kabukh and Goychay Azerbaijan from the reference point of scientific Research Institute of Fruit and Tea, located in Shirvan natural-economic region of Azerbaijan and is obtained from water extracts.

The material accumulated on the Azerbaijani garnet assortment shows that the Kyrmyz-Kabukh variety is one of the best local varieties of garnet. The fruit of this variety, which belongs to the varieties of folk selection, accumulates up to 61.3% of the juice of sweet and sour taste. Its fruits weigh about 225 g on average, their height and width range between 5-6 cm and there are about 500 intensely colored grains (seeds covered with a juicy shell) in one fruit.

The weight of one fruit in this variety is on average 210 g. The share of the peel in the total weight of the fruit is 77.91 g or 37.1%, the grains 132.09 g or 62.9% (total grains 810, each weighs 0.163 g).

The grains of this variety are very small, so the yield of juice is relatively high on average, 50.0% of the total weight of the fruit.

The object of the study was also liquid extracts from grinding and extraction of whole fruits with water bidistillate. For extraction from the raw material of the phytocomplex, water bidistillate was used as well as the pectolytic enzyme Fructozym P-6L (manufacturer-Erbsloeh Geisenheim AG). Bidistillate was obtained in their laboratory in the DB-2 apparatus (Russia). The enzyme preparation was one of those received from Germany and used in its study by the local company Quba Konserv-1.

Geographical location and natural conditions of the region of pomegranate fruits collection: The Shirvan natural and economic region is divided into mountainous and low-lying parts located in the South-Western foothills of the Greater Caucasus range and the Shirvan steppe.

The low-lying part of the Shirvan zone includes seven administrative divisions, including the Geokchay district, its center is the city of Geokchay. The reference point of the Research Institute of Fruit and Tea growing is located at the western edge of this city at an altitude of 94 m above sea level. Natural conditions are typical for the entire low-lying part of the Shirvan zone. The climate of the area is semi-dry with hot summers and warm winters. The absolute minimum temperature reaches 18°C, the summer maximum temperature reaches 42°C. Spring frosts end at the end of March and autumn frosts occur in the third decade of November. The annual precipitation rate in the area varies between 220-443 mm and the sum of active temperatures is 4445-4550°C. The soils are mostly light brown and meadow type. According to the mechanical composition of the soil of the experimental site, they belong to heavy loams. The plot area is 8.5 ha, the garden was laid out in 1963, since then it has been updated several times.

Organization of work and place of its holding: The fruit was collected at the beginning of November from all sides of 3-5 adult trees of the same variety, 20 pieces of fruit typical in shape, color and maturity were selected as an average sample and placed in a single layer in wooden trays. In these trays, they were delivered by covered transport to the laboratory processing and storage of Research Institute of Horticulture and Tea Industry of the Ministry of Agriculture located in the Guba district, about 500 km from Goychay reference point.

Chemical analysis: The analyzed sites were determined by the content of dry matter and water according to GOST (State standard of Russia) 28561-90, simple sugars by the method of Bertrand GOST 8756.134-87, organic acids titration in the presence of a color indicator in the international standard ISO 750-2013, ascorbic acid iodometric method according to GOST 28556-89, pH and potentiometric method according to GOST 26188-84.

Determination of the total amount of water-soluble polyphenols required their complete extraction into the extract, separation of the extract, filtration and titration with 0.1 N solution of potassium permanganate.

First, all substances oxidized by this reagent are titrated then the part of them that remains in the extract after processing it with activated carbon adsorb polyphenols. Based on the difference in the amount of potassium permanganate that was oxidized for the first and second time, the content of phenols is determined using 0.004157 as the conversion factor of 0.1 N mL of potassium permanganate solution into grams of phenols. This principle is also embedded in the basis of the method for determining tannins in medicinal raw materials in accordance with GOST 24027.2-80 and the corresponding article of the State Pharmacopoeia of the Russian Federation, which is also devoted to the definition of these substances in medicinal raw materials.

The content of extractive substances was determined in accordance with GOST 24027.2-80, which provides for complete extraction of these substances into the extract, separation of the extract, filtration, evaporation of the filtrate in a water bath until a solid residue is obtained and drying of the residue at a temperature of 100-105°C for 3 h.

Experimental processing: The pomegranate fruits washed under the tap were cut manually with a sharp knife into 4-6 approximately equal parts then weighed on a technical scale with an accuracy of 0.01-200 g of these slices and loaded into a glass jug made of high-strength Bio-glass of the stationary blender Endever Sigma-88 (Sweden). An equal amount of distilled water was added to them as well as the enzyme Fructozym P-6L in an amount of 0.03% by weight of pomegranate slices. This multi-functional blender with 5 high-speed grinding and mixing modes (up to 30000 rpm) is equipped with a thermo-regulator that heat the contents of the glass jug to a certain temperature up to 100°C and there is a shutdown timer after 1-60 min.

In the blender, its contents were crushed and mixed for 60 min in the 12000 rpm mode/min at a temperature that varied from 20-71°C depending on the test mode every 15 min, the blender stopped to avoid overheating. The office formed during that time of extract has occurred in the installation of prefabricated laboratory equipment arranged according to a simple scheme: in a flask Bunsen inserted a glass funnel with a double layer daneva paper filter to process the attached bulb pump to generate thrust. The filter residue was washed with 40 mL of distilled water when the pump was turned on.

Separated extracts were subjected to measurements and analysis that allow to judge their volume and the degree (percentage) of extraction of the total amount of extractive substances and individual phenols in the aqueous phase by the ratio between the extracted amounts of these substances and their total (initial) amounts in the extracted material. The solid residue remaining on the filter was dried in a laboratory drying Cabinet SH-DO-149 FG (South Korea) with forced ventilation and an observation window. The dried fruit residue was first weighed and crushed in a laboratory tube Mill control (Germany) with batch loading. Residual contents of simple sugars, titrated acids and water-soluble phenols were determined in the crushed powder.

Statistical analysis: The analysis and experiments were performed in three biological repetitions. The data obtained were processed statistically using the Microsoft Excel spreadsheet package and presented as arithmetic averages.

RESULTS

As already mentioned that the Pomanox pomegranate extract technology is designed conceptually to extract and use mainly soluble phenols from the juice part of the pomegranate fruit. Therefore, this extract is produced using juice varieties grown in the Mediterranean regions of Spain, which belong to the most popular group here "Mollar".

In Azerbaijan, the head of the best varieties of pomegranate juice on the right is a grade Kyrmyz-Kabukh. Relationship between the individual components of the technical composition of the fruit of this variety were established. The results are presented in Table 1.

The data shows that the juice, seeds and rind in the total weight of the fruit account for 59.87, 13.95 and 26.18%, respectively.

Table 1: Balance between the individual components of fruit of the pomegranate (Variety Kyrmyz-Kabukh)

Pomegranate fruit and its parts	Weight (g)	Share in the total mass of the fruit (%)
Fruit as a whole	183.74	-
Juice	110.00	59.87
Seeds	25.64	13.95
Peel	48.10	26.18

Table 2: Chemical composition of the whole pomegranate fruit and its individual parts (Variety Kyrmyz-Kabukh)

Indicators	Fruit as a whole	Juice	Seeds	Peel
Dry matter (g/100 g)	29.80	18.60	46.50	46.50
Monosaccharides (g/100 g)	14.57	13.34	7.05	21.40
Sucrose (g/100 g)	0.35	0.53	0.23	0.02
Titrated acidity (for citric acid) (g/100 g)	2.55	2.99	5.19	1.30
Water-soluble phenols (g/100 g)	1.11	0.15	0.15	3.80
Ascorbic acid (mg/100 g)	15.04	13.20	4.93	24.65

Table 2 shows how these parts differ from each other in the content of water-soluble phenols and some other phytochemicals. Data showed that the content of phenols juice (0.15 g/100 g) and seeds (0.15 g/100 g) is significantly inferior to the peel (3.80 g/100 g). The ratio between the content of phenols in 100 g of peel and the content of phenols in 100 g of juice is equal to 3.80/0.15 = 25.33.

Using the data from Table 1 and 2, it is easy to calculate how many phenols (g) are contained in certain parts of the fruit of the Kyrmyz-Kabukh variety taking into account the mass ratio between them at the time of analysis:

- Juice phenols: $59.87\times0.15/100 = 0.089805$ g
- Seed phenols: $13.95\times0.15/100 = 0.020925$
- Peel phenols: $26.18\times3.80/100 = 0.99484$ g
- Phenols from the whole fruit: 0.089805+0.020925 +0.99484 = 1.10 g

The ratio between the content of phenols in 48.10 g of peel and 48.10 g of juice (in accordance with the masses of these parts at the time of analysis) in this case is equal to: 0.99484/0.089805 = 11.08.

Translating the above data on the amounts of polyphenols (0.089805/110.00 g of juice, 0.020925/25.64 g of seeds and 0.99484/48.10 g of peel) into data on the mass fractions of polyphenols of juice, seeds and peel in their total amount (1.10 g) allows to show this difference in a different and more visual form as shown in Fig. 1.

As can be seen from Fig. 1, the phenolic potential of the whole fruit is formed mainly due to the phenols of the peel. In the total amount of phenols contained in one fruit of the Kyrmyz-Kabukh variety with a mass of 183.74 g, the share of phenols in the juice accounts for only 8.1 wt.%. In the total

Table 3: Content of residual amounts of total sugar, titrated acids and phenols in the dried solid parts of whole pomegranate fruits at different temperatures (Variety Kyrmyz-Kabukh)

Temperature	Yield of dehydrated dry residue (g/100 g of fresh fruit)	Total sugar (g/100 g)	Titrated acidity (g/100 g for citric acid)	Water-soluble phenols (g/100 g)
38°C	18.20	23.58	4.69	3.01
50°C	17.20	18.78	3.72	2.67

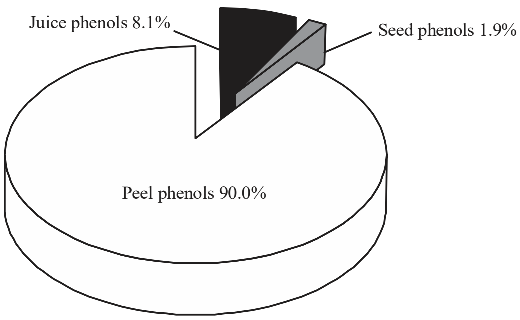

Fig. 1: Percentage of phenols in juice, seed and peel of whole fruit varieties Kyrmyz-Kabukh

Percentages between the juice, seed and peel phenols were calculated based on the percentage of each fruit part in the total mass of the whole fruit at the time of analysis

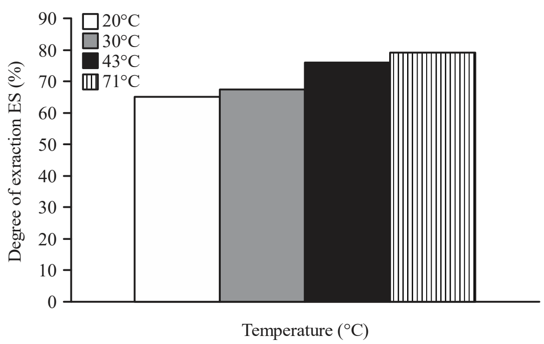

Fig. 2: Change in the degree of extraction of Extractive Substances (ES) from whole pomegranates into the aqueous phase (Variety Kyrmyz-Kabukh)

amount of phenols contained in one fruit of this variety, the phenols of seeds are assigned a share equal to 1.9%. Of course, these indicators may vary depending on the type of pomegranate.

Analysis have shown that another local variety, the Azerbaijan variety has an average weight of 208 g per fruit. In the total mass fraction of peel accounts for 38.76% and it is much more than the varieties of the Kyrmyz-Kabukh (26.18%). Therefore, it is not surprising that the number of phenols contained in one fruit of this variety is significantly ahead of the variety Kyrmyz-Kabukh (2.28 g/100 g against 1.11 g/100 g in the variety Kyrmyz-Kabukh).

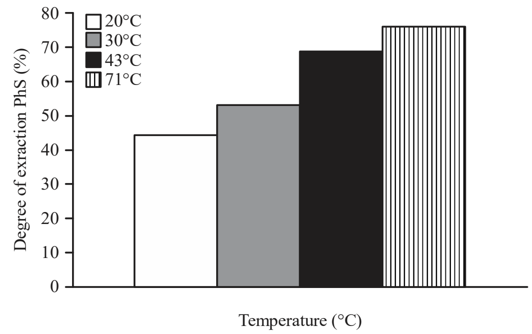

Fig. 3: Change in the degree of extraction of Phenolic Substances (PhS) from whole pomegranates into the aqueous phase (Variety Kyrmyz-Kabukh)

The use of Azerbaijan fruit extract instead of Kyrmyz-Kabukh fruit can, of course, provide an increase in the yield of phenols but this increase will be so small that it will not significantly affect the yield of polyphenols. And this applies to the overall polyphenol potential, which is formed mainly due to the polyphenols of the peel.

It can be justified in this case, the calculation for the isolation, purification and use of only the phenols of the juice in the form that it is practiced by the producers of the Pomanox Probeltibio extract. After all, this significantly reduces its economic performance.

Is it not better to process this raw material with the expectation of extracting not only the phenols of the juice but also the phenols of the fruit peel. Thus it can be assumed that the second approach should be more effective than the first.

In the industrially applied pomanox Probeltibio extract technology, the calculation is made for extracting the juice part of pomegranate fruit into the extract of phenols, so it adheres to a relatively soft extraction mode within the temperatures of 4-30°C. In the industrially applied POMx Pom Wonderful extract technology, phenols are extracted at temperatures of 43-71°C, with the expectation of isolating, cleaning and using the peel phenols.

Figure 2 refer to the results of experiments on the extraction of whole fruits with distilled water in a ratio of 1:1.2 while grinding and stirring them for 1 h in the presence of the pectolytic enzyme Fructozym P-6L.

These experiments were conducted according to the same predetermined scenario. Their peculiarity was that when they were carried out, all the technological parameters of extraction, except for the temperature were the same.

Figure 2 shows that in experiments with this procedure at relatively mild temperatures of 20 and 30°C, provided by Pomanox extract technology, the degree of extraction of the total amount of extractives was 65.1 and 67.1% of their initial content in Azerbaijan pomegranates, respectively. While the extraction of these substances from the same raw material under the same conditions but at relatively harsh temperatures of 43 and 71°C, used in the industrially applied POMx extract technology, provided a more complete extraction of extractives at the level of 76 and 79.0%, respectively.

As for the degree of extraction of phenols, the difference between the soft and relatively hard modes of heat treatment is even higher: at temperatures of 20 and 30°C, the degree of extraction of phenolic substances was 44.1 and 53.0%, respectively and at temperatures of 43 and 71°C extraction was 68.7 and 76.0%, respectively (Fig. 3).

From the data in Table 3, it is possible to judge the yield of dried solid residues from water extraction of whole pomegranates of the Azerbaijan variety at temperatures of 38 and 50°C and their content of residual amounts of total sugar, titrated acids and phenols (as a percentage by dry weight).

It was suggested that extraction at a temperature of 50°C is preferable to extraction at a temperature of 38°C in the sense that it reduces the amount of new waste in the form of post-extraction residue and therefore reduces the loss of phenols.

However, arguing in favor of relatively high temperatures, it is impossible not to take into account the fact that the plans of the producers of Pomanox extract did not include increasing the yield of this extract due to the phenols of the peel. On the contrary, they see the advantage of their product in the fact that its active components are represented almost entirely by pomegranate juice phenols.

Then it can offer an approach that may suit them. It is a combination of processes for obtaining extracts of both types in the same technology.

The temperature inside the production room can be selected as the most suitable temperature for the first stage of extraction. Suppose, the temperature inside this room is 20°C. Then the first stage of pomegranate extraction will be carried out at this temperature. According to the results of the first stage, about 44% of the total weight of phenols that were originally contained in the processed raw materials will be extracted into an extract. For the second stage extraction can be selected to be any temperature in the range of 43-71°C. The second stage at a temperature of 43°C will give the opportunity to extract for 24.5% more polyphenols than a single extraction at 20°C. The second stage at a temperature of 71°C will give the opportunity to extract for 32.0% more polyphenols than a single extraction at 20°C. The second stage extraction at a temperature of 43°C allows to increase the degree of extraction of phenols to 55.8% from their initial content in raw materials. Carrying out the second stage of extraction at a temperature of 71°C allows to increase the degree of extraction of phenols to 72.5% of their initial content in the raw material.

Extraction from the first stage of extraction will consist mainly of juice phenols and extraction from the second stage of extraction from phenols of solid parts of pomegranate fruits.

Results have shown that extracts from the first and second stages of the extraction procedure contain from 0.50-1.25 wt.% polyphenols. This is impressive, since this content of polyphenols is quite sufficient for them to be included in the category of food additives with antioxidant properties, while still being diluted.

The results of analyses, in some interpretation can also be reduced to the fact that the fruits of the Kyrmyz-Kabukh variety contain a total of 29.80 g/100 g of dry substances (all the rest is water).

The water-soluble part of them accounts for approximately 18.58 g (monosaccharides 14.57 g+sucrose 0.35 g+organic acids 2.55 g+polyphenols 1.11 g) or 62.35% and the insoluble part-11.22 g.

The tested temperature conditions are not so rigid as to ensure complete extraction of the soluble components of the raw material into the extract. Therefore, it is not surprising that the weight of the dehydrated post-extraction residue in some of the variants of enzymatic extraction tested was 17.2-18.2 g/100 g of fresh fruit (Table 3) instead of the calculated 11.0-12.0 g/100 g of fresh fruit.

This indicates that the utilization rate of the feedstock with the completion of enzymatic water extraction remains low and actualizes the issue of processing the insoluble solid residue.

DISCUSSION

The effectiveness of the research is quite high, both in terms of implementing the idea of more complete use of the functionality of the Pomanox extract technology in terms of increasing the utilization rate of raw materials and taking into account the practical solution of this idea. The proposed innovation is to include in the further processing of the part of the raw material that remains after its enzymatic water extraction in the mode provided by this industrially used technology at relatively mild temperatures.

Processing of the solid residue in the second stage of extraction is effective in that as a result of its implementation at 43 or 71°C, the total yield of polyphenols significantly increases and reaches 55.8 or 72.5% of their initial content in the raw material.

Thus, the results of the conducted research indicated that the extraction of this specific raw material should be carried out not in one but in 2 stages: in the first of them-within a soft temperature regime of 18-30°C, in the second within the boundaries of relatively hard temperatures of 43-71°C. From the extract of the first stage, polyphenols of the peel can be obtained.

As an innovation, the second stage of extraction at relatively high temperatures of 43-71°C contributes to the fact that more ellagic acid is released into the extract, which does not dissolve well in cold water. Therefore, in the extract from the first stage of the process, which is carried out at ambient temperature, ellagic acid is practically absent. This can play a crucial role in the therapeutic use of polyphenols from selective extraction in the first and second stages of the process.

Further processing of extracts from the first and second stages of extraction can be carried out in exact accordance with the pomanox Probeltibio extract technology. Polyphones rind and polyphenols solid parts of fruit were obtained from first and second stage of extraction.

These statements do not contradict the conclusions that have already been made by the authors of this article based on the results of their previous studies[13-16]. This is confirmed by the fact that the scheme of complete (without residue) processing of pomegranate fruits in its final part can be almost the same as the scheme proposed earlier[17]. After purification from polyphenols, the extracts retain valuable nutrients (glucose, fructose, organic acids). They are transparent and sweet to the taste, which determines the direction of their further processing. This may be their evaporation under vacuum. The concentrate can be used as a hydrophilic flavoring agent. Processing of solid residues can include their convective drying, grinding into a fine powder, extraction under supercritical conditions and sieving of the fat-free residue to obtain individual lipophilic complexes of seeds and pomegranate peel in the extraction stage and in the sieving stage.

The post-extraction solid residue is first processed in a pressing device then dried by convective method to a residual water content of $\leq$8 wt.% and ground into a fine powder.

The powder contains storage lipids of seeds and structural lipids of the rind, the extraction of which makes it possible to obtain promising products for use in the pharmaceutical, perfume and food industries.

Lipids are extracted in a CO_2 extractor at a temperature of 75°C and a pressure of 400 bar, first for 1.5 h in the CO_2 extractor with carbon dioxide, then for another 0.5 h with a mixture of carbon dioxide (99 wt.%) and ethyl alcohol (1 wt.%). According to the results of the first stage extraction get CO_2 extract with the properties of pomegranate seed oil and the second with the properties of fatty substances of the rind.

Also using a vibrating screen, the skimmed residue, which has well preserved the shape of a fine powder, is sieved into fractions with a particle size of 150 µm (protein-carbohydrate flour) and higher (food fibers), which will ensure full (without residue) use of the raw material.

The advantages of this solution are obvious: Raw material is used completely without residue, the range of products with the natural power of pomegranate is expanded, there is an opportunity to reduce the price of the extract and make them available to the poor, since the cost of the raw material can be divided between several end products. This will make the reworking process clean and eliminate its main drawback.

Instead of removing the solid residue to the landfill, it is better to ensure that there is no waste at all.

Dhinesh and Ramasami[18] believed that despite the high demand for potential products that can give complex processing of pomegranate fruits, their production is still not developed due to the lack of scientifically sound technological developments with prospects for commercialization.

Extracts of whole pomegranate fruits and by-products of pomegranate juice production are an excellent source of monomers, which are well and relatively inexpensive to extract with water. Leonova and Klimochkin[19] believed that natural extracts can be considered food additives with antioxidant properties only if they contain at least 0.1 wt.% antioxidants. Masci *et al.*[20] came to the conclusion that the antioxidant capacity of whole pomegranate extracts and their skins is directly related to the content of common phenols and their antiproliferative activity is related to the content of ellagic acid. The critical step is the isolation and purification of polyphenols. The solvent can be removed by concentrating with ultrafiltration (UV)[13]. The disadvantage is that the membrane is contaminated, which can disrupt the process and the time it takes to complete the process. The separation process must be repeated several times. Solid-phase

Extraction (SPE) is also used to remove the solvent. This is a fast method that uses a sorbent (solid stationary phase) to concentrate and separate the target component or components followed by elution (washing out) with a suitable solvent[17,21]. After any of these processes, the extract must be dried to obtain a powdery form. Alternatively, they also offer supercritical liquid extraction of the raw material itself, which makes it possible to obtain the final product in the form of a powder without using final drying[15,22]. CO_2 is inexpensive, non-toxic, non-flammable and non-corrosive making it an ideal solvent for natural products. However, in this method, polyphenols are extracted poorly. Therefore, Shi *et al.*[23] believed that this method can only be considered a method of the future for the time being.

Water can be considered the most acceptable of the solvents. Moreover, polyphenols obtained using a pure hydro-process are the most popular pomegranate polyphenols. This can be seen in the way things are going for manufacturers of Pomanox polyphenols. This extract is obtained without the use of organic solvents, that's why it is very popular in Europe. It has great potential to dominate the pomegranate supplement market in the United States.

CONCLUSION

This study concludes that it is appropriate to introduce some conceptual innovations in the industrial biotechnology of whole pomegranate fruit extract. Conceptually, this study comes up with a new solution, the implementation of which would ensure the receipt of both of the above extracts without significantly updating the basic elements of the 2 technologies discussed above but at the same time, it would be devoid of the characteristic shortcomings.

SIGNIFICANCE STATEMENT

This study expands the functionality of the technology for the production of pomegranate extracts from whole pomegranate fruits by including additional elements that deepen the processing of raw materials. It allows you to create a workable multi-product production of a continuous type with a flexible system of gradual deepening of the reworking process up to the full use of raw materials. It is an aid for conducting the recycling process in an environmentally friendly modern style and expanding the range of products with the natural power of pomegranate. This rational approach has not yet been studied or proposed, although its advantages are obvious, since the practice of obtaining pomegranate extracts is associated with the loss of a particular part of polyphenols and the formation of a large amount of so-called waste in the form of solid fruit residues.

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