Qualitative purification of pomegranate juice using electro flotation

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Abstract. The article describes the research conducted on qualitative cleaning of pomegranate juice using electro flotation, method of cleaning juice, also results of conducted experiment and other results related to this research. As a result of the research, it was found that the method of electroflotation provides effective irrigation of pomegranate juice. Factors affecting the electroflocation process were determined and their alternative values were found. Organoleptic analysis was conducted with the participation of scientific staff and showed that electroflotation processing improves the appearance and taste of pomegranate juice.

1. Introduction
Nowadays growing the fruit of pomegranate in the world consists of 3.086 million tons. In particular, it was harvested in India 900 thousand tons, Iran 800, China 290, Turkey 220, the USA 200, Pakistan 120, Afghanistan 90, Tunisia 85, Azerbaijan 82, Syria 79 and Uzbekistan 60 thousand tons in 2016 [1]. That is why most of scientific researches are directed to introduce technologies in order to accelerated develop processing the pomegranate juice, to produce juice, concentrate and other assortments.

There were created wide range of scientific designs on storing fruit-vegetables and implementation of processing technologies, producing exporting juices in food industry of our republic and they were implemented to the production. In the Action strategy on further development of the Republic of Uzbekistan were set tasks such as “deepening structural changes and deep development of producing agrarian products, further strengthening food safety of the country, widening producing ecologically pure products, to increase export capacity of agrarian sector” [2]. At this point, scientific researches directed to creation manufacturing technologies of exporting productions is of topical issue.

In this work, we will look at the experimental stand, the method of juice purification and the results of the experiment and the others in the study conducted on the qualitative purification of pomegranate juice using electro flotation.

2. Results and discussion
It is known that when dividing non-uniform liquids in the industry: suspensions, emulsions are performed mainly on the account of tender or centrifugal force. On the basis of centrifugal force, a complex device is considered, centrifuges and, in most cases, the purification process are used.
In the food industry, liquid products are considered to be heterogenic system and are structured from two phases to a dispersing environment and a dispersing phase. If in the liquid system there is a strong contact between the dispersing medium and the dispersing phase, such liquids are hydrophilic, the bond medium consists of water, and its hydrophilic shell is surrounded by aqueous products. To these is an example of the suspension of starch. If the interdependence in the phase with the environment in a system is weak, they are called hydrophobic systems. These are examples of protein suspension, oil and water emulsions.

If in the liquid phase the gas bubbles of the dispersing phase stick out, this process is called the flotation process. At present, different methods of flotation have been developed [3]. One of these is electroflotation in which positive results have been obtained in many areas of the food industry and in the processing of wine materials and others. Therefore, we conducted the study on the qualitative purification of pomegranate juice by this method.

In an experimental study of pomegranate juice purification, we examined the experimental electroflotation stand and performance principle.

For the first time, a research stand for monitoring the process of electroflotation was established in Moldova for the purification of grape juice. Later, this structure was improved. We have made an experimental stand based on this improved principle scheme. Electroflotation research the principle scheme of the laboratory stand was presented in figure 1.

![Figure 1. Principle scheme of electro flotation device.](image-url)

The electro flotation laboratory research stand consists mainly of the following: a glass container with cylindrical electrodes (5-cathode, 2-anode) with a capacity of 5 l as a working chamber, a constant current source 5, a laboratory autotransformer 6, processing products incoming 3 and outgoing 7 juice from the processing consisting of stripping pots and separated foam 4 and measuring control device.

Electro flotation on the stand is performed in the periodical mode. In its operation, a mixture of turbid juice is put in a container and filled, then connected to electricity. The alternating current is given to the anode and cathode electrodes after it becomes a constant. In this case, the lower electrode begins to separate from the cathode in a uniform gas bubbles. Bubbles move from the mixture of juice, by itself sticking the hanging residues in the juice and take it to the top, thereby forming foam of bubbles stuck in colloidal particles at the top of the container. From time to time, the foam formed
from these bubbles is removed. The process is continued until the juice is purified, and the purified juice is taken from the bottom and put in a new one from above until the container is full, and the process is continued.

In the qualitative passage of the electro flotation process, it is important what kind of material the electrodes are made of. The best electrodes are inert materials, which does not melt during the process and does not give all sorts of additional reactions to the juice, etc. To such electrodes are used platinum, graphite and coal [4, 5].

In the experiment of purification of pomegranate juice by electro flotation, electro flotation is determined as the main task of determining the purification properties: the effect of the intensity of the current on the process, the effect of the placement of electrodes in the working chamber, the properties of foaming, the temperature of the juice in the electro flotation process and the height of the layer of juice.

For the experiment, pasteurized pomegranate juice (temperature 45-50°C) was obtained.

In the study of the effect of electricity power, its effect on the speed of pomegranate electro flotation was determined. In it, the current power was changed from 3.2 to 50 mA/cm². The experimental data obtained were included in table 1.

Table 1. Influence of electricity power on electro flotation.

| No. of the experiment | Density of electricity mA/cm² | Duration of the project, min. | Ratio of the volumes, % | $V_s/V_0$ | $V_v/V_0$ | $(V_s+V_v)/V_0$ |
|-----------------------|-------------------------------|-------------------------------|-------------------------|-----------|-----------|-----------------|
| 1                     | 2.5                           | 32                            | 66.7                    | 33.4      | 100.0     |                 |
| 2                     | 5.0                           | 25                            | 67.8                    | 33.1      | 100.9     |                 |
| 3                     | 10                            | 17                            | 68.2                    | 32.6      | 100.8     |                 |
| 4                     | 15                            | 7.5                           | 68.2                    | 32.4      | 100.6     |                 |
| 5                     | 20                            | 7                             | 68.2                    | 32.4      | 100.6     |                 |
| 6                     | 25                            | 12                            | 69.6                    | 31.1      | 100.7     |                 |
| 7                     | 30                            | 16                            | 68.3                    | 32.6      | 100.9     |                 |
| 8                     | 35                            | 18                            | 66.4                    | 33.7      | 100.1     |                 |
| 9                     | 40                            | 19                            | 70.1                    | 30.0      | 100.1     |                 |
| 10                    | 45                            | 20                            | 70.0                    | 30.0      | 100.0     |                 |
| 11                    | 50                            | 21                            | 72.0                    | 28.6      | 100.6     |                 |

$V_s$ in the table is volume of purified juice; $V_v$—volume of foam; $V_0$—volume of purified juice.

The results obtained after this experiment, that is, when purifying pomegranate juice after pasteurization, the binding of the vine density, were presented in figure 2.
The figure, that is, the results obtained for grape juice in the Moldavian Institute of food scientific research for comparative analysis, was also cited. Experimental data have shown that when purifying pomegranate juice, the electro flotation rate increases from 15 to 20 mA/cm² of the vine density. This situation is also confirmed in grape juice. Only in it 20-25 mA/cm² [6-8].

Grape juice and pomegranate juice differ in quantity, although the binding curve of the vine density and duration is similar in quality. Because the viscosity of pomegranate juice is small from the viscosity of grape juice, the viscosity of grape juice in grape juice is more than in pomegranate juice.

Thus, it can be assumed that the optimal mode of purification of pomegranate juice in the electricity density is 15-20 mA/cm². According to the purpose, it is necessary to indicate that even when purifying pomegranate juice by the method of electro flotation, 1-1.5% of the sediment is formed.

The analysis of experimental data shows that in a small amount of electricity density (2-5 mA/cm²) the process goes slowly (30 - 34 minutes) and at this time juice becomes weakly saturated with gas bubbles. The concentration of gas bubbles will be much less, they will begin to move upwards, gluing hanging waste on themselves. With an increase in the density of the electricity in the duration of time, the speed of the process increases, the concentration of gas bubbles in the juice also increases. With an increase in the density of the electricity in general, the gas bubbles of the juice increase as the saturation level increases.

In the process of electro flotation, the optimum amount of electricity density is 15-20 mA/cm² for pomegranate juice, in grape juice 20-25 mA/cm², gas bubbles are increased, and only a part of them is added to the flotation, the rest are added to the foam, which is formed upwards without hanging particles. The foam of the bubbles causes the flow of juice into the body. Bubbles form as a group of flows, increasing the density of foam and reducing the quality of flotation.

The increase of electricity density may also form big foams. The results of conducted experiments show that as optimal amount of electricity density increases, it reduces electro flotation speed. That is why optimal level of the electricity density leads to effective operation of the process.

Electroflotation process is different in experimental stand: anode below and cathode on the top, electrode on the top when checked horizontally, cathode below of electrodes (in horizontal position in the shape of plate), and anode is between dishes in the shape of vertical rod and it was better than other variants.

Same happened with experiment result, electricity density in foaming had influenced on structure of foam and it's density as well. The higher electrical density, the more foam in the gas bubbles concentration.

Experiments on electro flotation were conducted in different temperature media from 20 to 50°C. The electricity density was kept constantly at 18 mA/cm² which was dependant on the process of electricity density in conducting juice in high temperature with different electricity density.

It was known from the data of the experiment, that during the electrofloation process there is dependence between the temperature and duration, temperature increase may lead to the increase of the process, and flotation speed noticeably increase in high temperature from 5 to 18- 20°C.

Hence the electricity density was 30 mA/cm² in conducted three experiments, on the layer of liquid on the cathode top 0,40,80 and 100 cm characterized speed of electro flotation (table 2).

Therefore, from the layer of liquid connected to cathode (H=0 cm) after 4 minutes will be floated particles under the influence on the average 30 - 40% of electro flotation. At this time existing layer of the liquid on 20 cm above the cathode will be close to 20%, and layer in the liquid will less floated from 80 cm to 11%. So, the higher the liquid layer on the cathode, the lower electro flotation process.

We can conclude from above conducted experiments, that in electro flotation of pasteurized pomegranate juice purification initial concentration of hanging particles in any time is 2.0 – 2.5%, and is same with the volume of formation of aggregates of hanging particles with liquid adhesive bubbles while processing in the equipment not higher than 60 cm.
Table 2. Values of electric flotation velocities of 0.40.80 and 100 cm in the liquid layer at the top of the cathode.

| No of the experiment | Duration of the process, min. | Concentration of hanging particles in different height (in %) | No. of the experiment | Duration of the period, min. 80 cm | Concentration of hanging particles in different height (in %) |
|----------------------|-------------------------------|-------------------------------------------------------------|----------------------|-----------------------------------|-------------------------------------------------------------|
|                      |                               | 0 20 cm 60 cm 70 cm                                       |                      | 0 20 cm 60 cm 70 cm               |                                               |
| 1                    |                               | 0 3.3 3.3 3.3 3.3                                        | 4                    | 3.3 3.8 3.8 3.8 3.8              | 2.2 2.2 2.8 2.8 2.8                                   |
|                      |                               | 4 1.8 2.5 3.0 4.0                                        | 8                    | 0.8 0.8 0.8 0.8 0.8              | 0.8 0.8 0.8 0.8 0.8                                    |
|                      |                               | 12 0.8 0.8 0.8 0.8                                       | 12                   | 3.8 3.8 3.8 3.8 3.8              | 3.2 3.8 3.8 3.8 3.8                                   |
|                      |                               | 16 0.8 0.8 0.8 0.8                                       |                      | 0.8 0.8 0.8 0.8 0.8              | 1.9 1.9 2.2 2.2 2.2                                   |
| 2                    |                               | 4 2.7 3.6 3.6 4.1                                        | 4                    | 0.9 0.9 0.9 0.9 0.9              | 1.3 1.3 1.3 1.3 1.3                                   |

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When electroflotation purification the electricity density (1 experiment series) is 30 m/cm² and 40 m/cm² (2nd experiment series) results of the analysis are given in the table 3.

Table 3. The chemical composition of pomegranate juice till electro flotation (1-2 test) and after electro flotation (3-6 tests).

| Experiment series | No. of the samples | Height of selected samples, cm | Dry substance, % | Sugar, % | Titrated acid % | Total and dryer substances, g/l | Nitrogen amino acid, mg/l | pH | Fe, mg/l | Cu mg/l | Ascorbic oxidase, mg/g | Polyphenol oxidase, mg/g | Peroxidase, mg/g | Polyphenol oxidase, mg/g | Polyphenol oxidase, mg/g |
|-------------------|--------------------|--------------------------------|-----------------|---------|----------------|-------------------------------|--------------------------|-----|---------|---------|-----------------------|----------------------|-----------------|-----------------------|-----------------------|
| 1                 | 1                  | 19.0 15.3 0.89 0.81            | 229.6           | 3.35    | 13.1          | 1.0                           | 1.5                      | 5.6 | 2.8    | 2.8    | -                     | -                    | -               | -                     | -                     |
|                   | 2                  | 19.0 15.6 0.89 0.92            | 302.4           | 3.35    | 12.5          | 0.8                           | 1.4                      | 5.6 | 3.1    | 2.8    | -                     | -                    | -               | -                     | -                     |
|                   | 3                  | 19.0 15.3 0.89 0.86            | 302.4           | 3.35    | 14.6          | 1.1                           | 1.5                      | 3.9 | 3.1    | 2.8    | -                     | -                    | -               | -                     | -                     |
|                   | 4                  | 19.0 15.3 0.89 0.90            | 240.8           | 3.3     | 13.7          | 0.4                           | 1.25                     | 5.0 | 3.9    | 3.1    | -                     | -                    | -               | -                     | -                     |
|                   | 5                  | 19.0 15.6 0.89 0.81            | 229.5           | 3.3     | 12.5          | -                             | 1.1                      | 5.0 | 3.6    | 3.1    | -                     | -                    | -               | -                     | -                     |
|                   | 6                  | 19.0 15.3 0.89 1.05            | 229.6           | 3.3     | 12.5          | -                             | 1.25                     | 5.0 | 3.6    | 3.3    | -                     | -                    | -               | -                     | -                     |
| 2                 | 1                  | 17.6 14.6 0.79 0.81            | 202.4           | 3.4     | 15.2          | 0.5                           | -                       | -   | -      | -      | -                     | -                    | -               | -                     | -                     |
|                   | 2                  | 17.2 14.3 0.77 0.73            | 254.6           | 3.4     | 16.4          | 0.4                           | -                       | -   | -      | -      | -                     | -                    | -               | -                     | -                     |
|                   | 3                  | 17.4 14.3 0.77 0.76            | 255.2           | 3.4     | 17.0          | 0.3                           | -                       | -   | -      | -      | -                     | -                    | -               | -                     | -                     |
|                   | 4                  | 17.4 14.3 0.78 0.71            | 234.7           | 3.4     | 16.1          | 0.3                           | -                       | -   | -      | -      | -                     | -                    | -               | -                     | -                     |
|                   | 5                  | 17.4 14.3 0.77 0.68            | 203.2           | 3.4     | 17.0          | 0.3                           | -                       | -   | -      | -      | -                     | -                    | -               | -                     | -                     |
|                   | 6                  | 17.4 14.3 0.77 0.75            | 202.8           | 3.35    | 16.0          | -                             | -                       | -   | -      | -      | -                     | -                    | -               | -                     | -                     |

As can be seen from the table 3 data, regardless of the height of the samples obtained, that is, regardless of the distance of the juice layer from the electrodes, there are no significant changes in the...
indicators of pomegranate juice, despite the fact that electro flotation is carried out when the current density is high. In the process of electro flotation, significant changes in dry matter, sugar, titrated acid, tannic and dyes, nitrogen amino acids, iron, copper and oxidative enzymes do not occur.

3. Conclusion
Thus, as a result of complex inspections, no negative effects on the electrolysis process in pomegranate juice were found. It is possible to explain that there is no such effect as follows. First, the juice does not remain long (15-20 min) in the electroflotator and is carried out at the effect of low electrical current density in the order of 20-40 mA/cm². Secondly, the changes that occur as a result of electrolysis can occur not only in the liquid as a whole, but only in the part that is in direct contact with the surface of the electrodes, since electrochemical reactions occur in the place where the liquid and the electrodes overlap between the surface. The absence of turbulent flows in the equipment creates conditions for the fact that the bulk of the purified liquid does not come into contact with the electrodes.

As a result of the research, it was found that the method of electro flotation provides effective irrigation of pomegranate juice. Factors affecting the electro location process were determined and their alternative values were found. Organoleptic analysis was conducted with the participation of scientific staff and showed that electro flotation processing improves the appearance and taste of pomegranate juice. Practical and theoretical study of the process of electro flotation in the process of purification of pomegranate juice in laboratory and industrial conditions electro flotation method served as the basis for the expansion of various industries.

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