The Effects of Electrical Pulses on Structure of Cells of Plant Tissue.

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***Abstract* — the developed equivalent electrical circuit of juice-pulp mixtures and formulas for determining its electrical characteristics show that the defining element in the process of electroplasmolysis is intercellular fluid and the juice released during the crushing of the vacuoles of damaged cells**.

***Index Terms* — electroplasmolysis, electric pulses, resistance, biological raw materials, cell structure**

I. INTRODUCTION

In the technology of food production associated with the extraction of juice from the plant material, an important process is the destruction of semipermeable membranes of tissue cells. On the degree of destruction semipermeable membranes of cells plant material depends juice yield and the cost of its recovery. It is also important that, after processing the cellulose cell walls did not go into the juice, as this complicates its extraction and clean up. This can be achieved by pre-treatment of plant material before extracting juice various physical methods.
There are many ways to increase the permeability of the cell membranes of plant materials: mechanical, thermal, biological, and chemical processing, electrical, magnetic, acoustic, radioactive, radiation. The most common are: mechanical and thermal methods of processing of plant material. Enzymatic (biological) is rarely used because of the long duration of the enzymatic treatment. Electrophysical methods of processing are in the stage of optimization and experimental-production testing [1-4].
Promising is use for electric processing of food products short electrical pulses, whose effects on the material has a number of advantages over other electrical methods. The concentration of power and subsequent short-pulse influence on the processed material leads to a qualitatively new effects, which can be the basis for the development of new technological methods [5-8]. Also perspective is the use of combined methods of influence on plant tissue. In this case, in the first stage usually uses mechanical grinding crushing, cut into shavings, etc.

In existing technologies processing of plant raw materials are allowed considerable content of valuable components in the waste production, and existing technology recycling energy-intensive and lengthy. Therefore the maximum possible extraction of valuable components from plant material at the stage of extracting the juice from the pulp is an important task.

II.EXPERIMENTAL

To solve this problem were investigated the effect of electrical parameters: the energy density of plasmolysis, temperature, electric field on the electrical resistance of the juice-pulp mixture, the yield of juice, spontaneity and the overall yield of juice.

As the impacting factor used bipolar pulses with steep leading and sloping trailing front the Fig.1. As a criterion for evaluation of plasmolysis taken specific resistance of plant tissue.

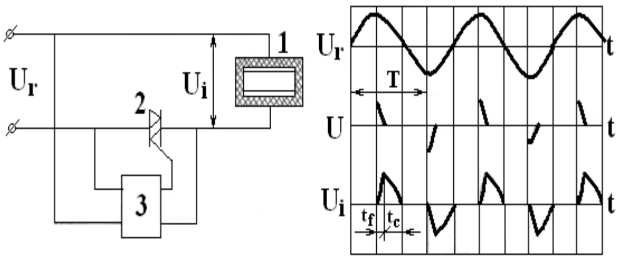


Fig.1. Circuit scheme of installation for the electroplasmolysis raw and timing diagram of voltage mains supply voltage alternating current Uc, control impulses Uy and processing pulses Ue: 1 - electrode cell, 2 - triac, 3 - the control unit.

Investigated the effects of electrical pulses on cell structure of plant tissue (Fig. 2). Microscopic and submicroscopic studies have established that under the action of electric pulses semipermeable membrane cell plasmalemma and tonoplast lose its semi-permeability and become permeable to the juice. Figure 3 shows the Microphotogram (a) and area of cross-sectional of the protoplast and the cell wall (b) of apple control sample, and in Figure 4 shows the microphotogram (a) and cross-sectional area of the protoplast and the cell wall (b) a sample of apple that been subjected by electric plasmolysis. In contrast to the control samples (Fig. 3), in the samples of processed by electrical pulses (Fig. 4) shows the significant changes. Figure 4 (b) shows a violation of the integrity of the cell protoplasm and visible breaks of the cell membrane, plasma membrane and tonoplast.

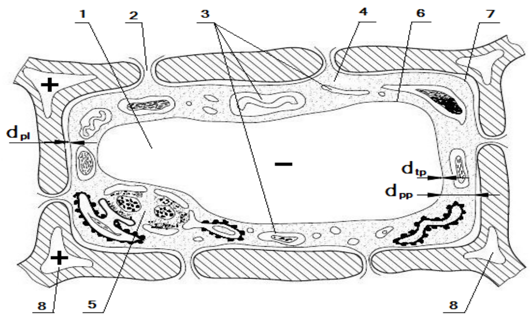
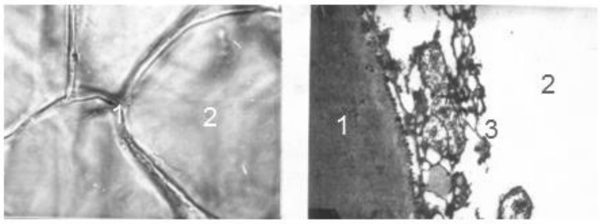
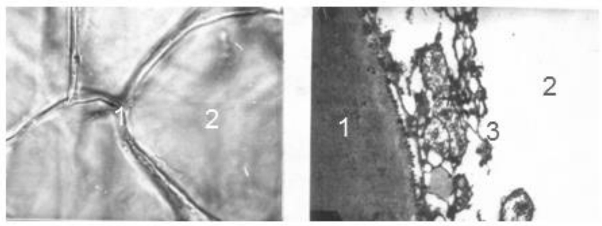


Fig.2. Schematic representation of the succulent plant cells: 1-vacuole 2 - plasmodesmata 3 - Golgi apparatus, and 4 – cytoplasm



a b

Fig.3 microphotogram (a) and cross-sectional area of the protoplast and the cell wall (b) control sample of apples: 1 - cell membrane, 2 - vacuole, 3 - tonoplast 4 - plasmalemma.



a b

Fig.4 microphotogram (a) and cross-sectional area of the protoplast and the cell wall (b) a sample of apple subjected by electric plasmolysis: 1 - cell membrane, 2 - vacuole, 3 - fragments of cytoplasm (the tonoplast and plasmalemma).

Were developed electrical equivalent circuit, Figure 5: a) - cells; b) - tissue c) - ground tissue; d) - chopped electroplasmolysed tissue.

Living cell succulent plant materials Fig. 1 contains: vacuole -1 core - 5; cytoplasm - 4 with tonnoplast - 6 and plasmalemma - 7 and intercellular spaces - 8. The crushed plant material is a piece of living plant tissue dampened with juice released from destroyed by grinding cell vacuoles

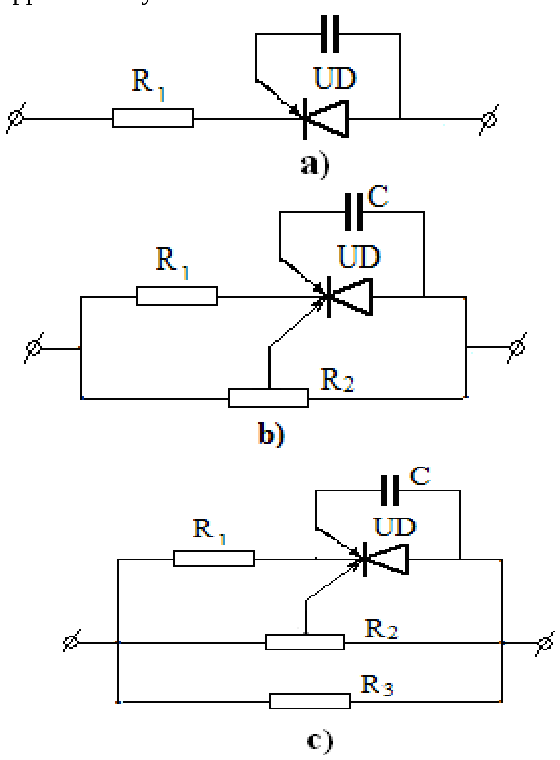
In the equivalent circuit, Figure 5:

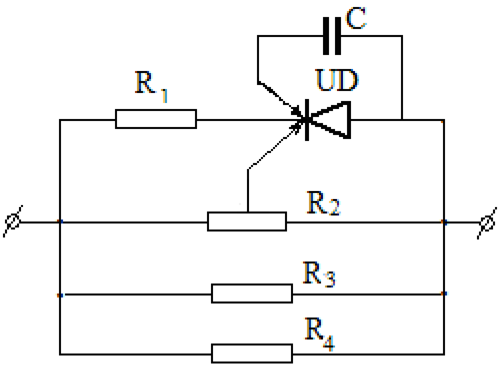
a) represented cells include: R1 - resistance of vacuoles juice, C - electric capacitance the cell membrane and UD - controlled diode of semipermeable membrane cells. From the equivalent circuit of the cell can be seen that the cell under normal conditions does not permeable, and its overall resistance za = ∞;

b) shows tissue plant material comprising: R2 - resistance intercellular fluid and za - the total resistance of the cell; from the equivalent circuit can be seen that on the total resistance of the tissue zb in normal conditions affects only resistance of the intercellular fluid. Considering that the measured resistivity tissue plant raw material under normal conditions is approximately 16 ohms. cm, and the resistivity of the intercellular fluid around 100 Om.sm, the coefficient of concentration of interstitial fluid in the plant tissue kb will be approximately approximately 0.006.

c) - presented ground tissue plant raw material which includes: R3 - resistance juice released from the cells of tissue in the during grinding and zb - total resistance of tissue; from equivalent circuit can be seen that on the total resistance of the ground tissue zs affects resistance juice released from the cells tissue during grinding R3 and the total resistance of tissue zb. Considering that the measured resistivity ground tissue plant raw material is about 6 kOm.sm., and the resistivity of the cell vacuole juice about 1.2 kOm. cm, the concentration ratio of vacuoles juice in ground plant tissue kc will be approximately 0.2.

d) - presented ground electroplasmolysed tissue plant raw material which includes: R4 - resistance juice that has lost its connection with the cell as a result of electroplasmolysis ground plant material and zs - total resistance of ground tissue; from the equivalent circuit of electroplasmolysed ground tissue can be seen that on the total resistance of the ground electroplasmolysed tissue zd affects the resistance of juice that lost its connection with the cell as a result of electroplasmolysis of ground plant raw material and the total resistance R4 ground tissue zs. Considering that the measured resistivity of plant raw material ground electroplasmolysed tissue is about 2.5 kOm. cm, and the resistivity of the vacuoles cell juice about 1.2 kOm.sm, the concentration ratio of vacuoles juice in electroplasmolysed ground plant tissue kd will be approximately 0.85.





d)

$$za = \sqrt{R_1^2 + \left(\frac{1}{\omega c}\right)^2}; \quad zb = \frac{\sqrt{R_1^2 + \left(\frac{1}{\omega c}\right)^2} \times R_2}{\sqrt{R_1^2 + \left(\frac{1}{\omega c}\right)^2} + R_2};$$

$$zc = \frac{\sqrt{R_1^2 + \left(\frac{1}{\omega c}\right)^2} \times R_2 R_3}{\sqrt{R_1^2 + \left(\frac{1}{\omega c}\right)^2} + R_2 + R_3}; \quad zd = \frac{\sqrt{R_1^2 + \left(\frac{1}{\omega c}\right)^2} \times R_2 R_3 R_4}{\sqrt{R_1^2 + \left(\frac{1}{\omega c}\right)^2} + R_2 + R_3 + R_4};$$

$$\rho_a \approx \infty; \quad \rho_b = \frac{\rho_e}{s_e}; \quad \rho_d = \frac{\rho_b \rho_3 \rho_4}{\rho_b + \rho_3 + \rho_4};$$

$$k_b = \frac{\rho_2}{\rho_5}; \quad k_{\tilde{n}} = \frac{\rho_1}{\rho_3}; \quad k_d = \frac{\rho_1}{\rho_4};$$

Fig.5. Equivalent electrical circuit of replacement of succulent plant raw material: a1) - cells; b1) - tissues c1) - ground tissue; d) - chopped electric electroplasmolysed tissue and formulas for determining the impedance: z1) - cells; z2) - tissue; z3) - ground tissue; z4) - chopped electric electroplasmolysed tissue and formulas for determining the resistivity: ρa) - cells; ρb) - tissue; ρc) - ground tissue; ρd) - chopped electric electroplasmolysed tissue. Where resistance: R1 - cell sap vacuole; R2 - interstitial fluid; R3 - juice after grinding of raw materials; R3 - juice after electroplasmolysis of raw materials, and measurement of resistivity: ρ1 – juice of cell vacuole; ρ2 - interstitial fluid; ρ3-juice after grinding of tissue; ρ4-juice after plasmolysis ground tissue; ρ5-tissues of plant raw material, and the concentration ratio: kb - intercellular fluid in the tissue; kc - juice after grinding tissue; kd - juice after electroplasmolysis ground tissue. C - capacity of the cell membrane, mF and DU - controlled diode.

III. CONCLUSION

1. Found that the resistivity of the plant tissue is one of the main physical characteristics of its state under electric processing.

2. Developed equivalent electrical equivalent circuit: cells; tissue ground tissue, chopped electroplasmolysed tissue

3. Obtained formulas for determining of the impedance: cells, tissue, ground tissue, ground electroplasmolysed tissue;

4. Derived formulas for determining the resistivity: cells; tissue ground tissue, chopped electroplasmolysed tissue.

5. Measured resistivity: sap vacuole cells, interstitial fluid, tissue plant material, tissue plant material after grinding, tissue plant material after grinding and electroplasmolysis;

6. Determined by the concentration ratio: interstitial fluid in tissue juice after grinding tissue juice after electroplasmolysis ground tissue.

7. Tracings were obtained cross-sectional areas of the protoplast and the cell wall in control and after plasmolysis, which showed that during electroplasmolysis undergoing profound changes in the cytoplasm of cells, violating the integrity of plasma membranes - plasma membrane and tonoplast.

BIBLIOGRAPHY

[1] M.C. Bologa Electro-chemical research and technology at the Institute of Applied Physics, Moldova / / Electronic processing materials. 2004, № 2 (226), p. 4

[2] Papchenko A.Y. Research the process of electro-processing of vegetable raw materials in order to intensify its juice-efficiency. Summary of the thesis. Odessa, 1979

[3] Ciobanu V.G. Improving the efficiency of processing of plant raw materials using electroplasmolysis. Summary of the thesis. Kiev. 1988.

[4] Papchenko A.Y., Popova N.A., Ciobanu V.G., M.C. Bologa Electroplasmolysis in technology of processing of red grapes. Electronic processing of materials. №. 2 (262), 2010, p. 80-82 5. Papcenco Andrew, Natalia Popova, Vasile Ciobanu. Electroplasmoliza grape juice extraction technology. Physics Conference of Moldova, CFM-2007, S. 165-166

[5] Natalia Popova. Analysis of energy consumption reduction opportunities specific to the production of canned vegetables appetizers. Physics lecture of Moldova, CFM-2007, S. 167-168

[6] V. Ciobanu, V. Bordeianu, Papcenco A., Bologa M., S. Berzoi electropasmoliza plant for vegetable raw materials with rotating electric field. Physics lecture of Moldova, CFM-2007, s.163 - 164

[7] V. Ciobanu, Papcenco A. Some characteristics of grapes crushed in preventive treatment in primary unification. Physics lecture of Moldova, CFM-2007, S. 161-164.