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Change Of Physiological And Biochemical Properties Of Plant Raw Materials During Thermal Preparation Before Extraction

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ABSTRACT

The article discusses the issues of thermal treatment of petals of oil-containing stone fruit crops with infrared rays in order to prepare them for extraction. It has been established that with intermittent infrared heat treatment, the temperature of the material does not rise above 58°C,, which contributes to the preservation of all useful substances in the composition of the material: lipids, proteins, vitamins, etc. The moisture content of the material will be within 7%. The penetration of infrared rays deep into the material creates conditions for the destruction of the cell walls of plant material, which creates favorable opportunities for direct extraction.

KEYWORDS

Petals of the cores of fruit seeds; infrared irradiation; plant material cell; heat treatment; extraction.

INTRODUCTION

Extraction is the process of selectively extracting one or more soluble components from solutions or solids using a liquid solvent - an epxtractant. In general, the process of extracting plant raw materials can be divided into four stages [1,2]:

- Penetration of the extractant into the pores of plant materials;
- Dissolution of the extracted substance with the extractant;

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- Diffusion transfer of the extracted substance to the surface of a piece or particle of raw material;
- Transfer of the extracted substance from the surface of the raw material into the liquid phase - the extractant.

It is known [3,4] that a plant cell contains an intracellular fluid (vacuole) surrounded by a complex membrane. The latter is composed of two membranes, between which there is protoplasm. Protoplasm (German Protoplasma from Old Greek πρῶτος "first" and πλάσμα "molded, shaped"), the contents of a living cell, including its nucleus and cytoplasm; material substrate of life, living substance of which organisms are composed. The membrane is a thin semi-permeable film that surrounds the cytoplasm and is responsible for the entry of various substances into and out of the cell. It is located under the cell wall.

The transfer of matter from the intracellular fluid outside the cell is carried out by molecular diffusion through this multilayer membrane. Inside the shavings, cells are densely surrounded by other cells. The substance from the inner cells must diffuse through these cells. The extremely simplified picture of the transfer inside the crushed raw material indicates a high resistance to internal diffusion.

To reduce resistance, crushed raw materials are subjected to heat or chemical treatment, and sometimes to electric current. As a result of these treatments, the protoplasm of the cell denatures and the permeability of the membrane increases sharply [5].

Modern technology for the production of cottonseed, sunflower and other vegetable oils provides for the maximum destruction of cells in the preparation process for the degreasing of oil-containing material [3].

In the technological line for the production of stone seed oil, a special place is occupied by the process of thermal preparation of kernels for degreasing. This process is the last one before the actual extraction of oil. The yield and quality of the oil mainly depend on the temperature regime, the duration of the process and other conditions of heat treatment. Heat treatment affects one of the main indicators of oil quality - its acid number.

In the dried stone nuclei, the processes of oxidation of oleic acid with the formation of peroxides, hydroxy acids and then low molecular weight acids occur, and they are the more intensive, the higher the temperature of heating the nuclei [3].

Low-temperature heat treatment promotes the hydrolysis of triacylglycerols with the formation of di- and monoacylglycerols and free fatty acids. High heating temperatures of seeds are accompanied by the binding of triacylglycerols and free fatty acids. Therefore, heat treatment should be carried out at optimal temperatures in order to minimize hydrolytic processes and at the same time prevent oxidative breakdown and lipid binding, which are inevitable at high temperatures [3].

As is known [6], globulins make up most (up to 90%) of the protein in the nuclei of fruit seeds. The rate and degree of protein denaturation upon heating depend on the heating temperature, the duration of the heat

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exposure, and the moisture content of the protein.

The denaturation of proteins is the more intense, the higher the temperature, the duration of heating and the moisture content of the protein.

Mineral elements were found in the cells and tissues of the nuclei of stone fruit cultures, which play a significant role in the processes of their vital activity. The content of individual elements in the nuclei of the seeds depends on the type of plant [3].

The main role of mineral elements is to increase the activity of various enzymes during the course of biochemical processes inside the cell. Carbohydrates, depending on the functions performed, are subdivided into reserve (starch), structural (cellulose) and protective. Mature stone fruit kernels contain a small amount of starch. Vitamins that are in the embryo and in other parts of the nuclei of fruit seeds are destroyed under the influence of high temperatures [6].

A distinctive feature of all stone fruits from other oil-containing materials is the presence in the core of the cyanogenic glucoside amygdalin $C_{19}H_{27}O_{11}CN$, which, under the influence of temperature (t> 70°C) and moisture (W> 14%), ultimately decomposes into benzaldehyde $C_6H_{12}CHO$ and hydrogen cyanide (hydrocyanic acid) HCN [3].

When the temperature rises, these processes get intensified, the enzymatic hydrolysis of amygdalin depends on the moisture content and temperature of the core, as well as on the duration of the heat treatment.

Hence, it can be concluded that the depth of biochemical processes in the nuclei of stone fruit under heat exposure depends on the initial moisture content of the material, temperature and duration of the process. As mentioned above, an increase in the temperature of heat treatment intensifies undesirable processes (oxidation of oil in nuclei, denaturation of proteins, hydrolysis of amygdalin, destruction of vitamins). All this together leads to a deterioration in the technological properties of the kernels, a decrease in the quality and healing properties of the resulting oil (an increase in the acid number, color change, bitter taste, unpleasant smell). Therefore, the heat treatment of the kernels of the fruit seeds must be carried out intensively and at such a temperature regime in which the kernels would be heated no higher than 70°C.

Modern technology for the production of cottonseed, sunflower and other vegetable oils aims maximum destruction of cells in the process of preparation for degreasing oil-containing material [3].

The existing process of heat treatment of the nuclei of fruit seeds is not focused on the maximum destruction of the cellular structure of the nucleus, but only pursues the goal of bringing the moisture content of the nuclei to the level of technological requirements (W=6÷7%). In this regard, when degreasing oil-bearing materials, the yield of the final product is not high (during extraction or first pressing). In order to improve the conditions for defatting, it is necessary to influence the cellular structure of the material by means of infrared radiation.

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The aim of this work is to study the thermal treatment of the petals of fruit seed kernels with infrared radiation to influence the cellular structure of the material.

RESEARCH METHOD AND MEANS

The study of the process of IR heat treatment of fruit seed kernels was carried out on a laboratory setup (Fig. 1), which consists of a working chamber, a control panel with instrumentation, control and signaling equipment.

Inside the working chamber 2, in its upper part, there are IR emitters 3. Quartz halogen lamps of the KGT 220-1000 type are used as IR emitters. The lamps are mounted so that it is possible to change the distance between them. Above the IR emitters there is a screen 4, which can be moved vertically. The voltage in the incandescent filament of the IR-lamps varies within the range of 0÷250 V using the voltage regulator PHO-250-10 11. The operating mode of the emitters is controlled by the measuring devices 13.

The internal surfaces of the working chamber are made of polished aluminum with a high reflectivity in the infrared region of the spectrum.

Measurement and registration of temperature in the layer of the hinge of the petals of fruit pits and the environment of the drying chamber during heat treatment is carried out by a digital multimeter UNI-T UT-39C + with primary measuring transducers in the form of thermocouples. Sensitive elements and wires of thermocouples are protected by screens 9 and heat-resistant protective sheaths made of asbestos fabric from directly incident IR radiation.

Mesh plate 1 is installed on screw supports which are fixed on the frame. The latest is rigidly connected with a scale 12 of the VLKT-500 M brand, designed to measure the loss of material mass during heat treatment.

On top of the chamber, four emitters are installed, which are connected to command-electric devices with a time relay, designed to regulate the duration of irradiation and "nap" - the time without irradiation.

The viewing window is provided for visual observation of the course of the heat treatment process. In order to comply with safety standards, all control and measuring devices are grounded; a lock that is triggered when the door of the working chamber is opened is provided and in that case the entire installation is automatically turned off.

In this way, the experimental setup using an IR power supply is equipped with all the necessary instrumentation and control equipment.

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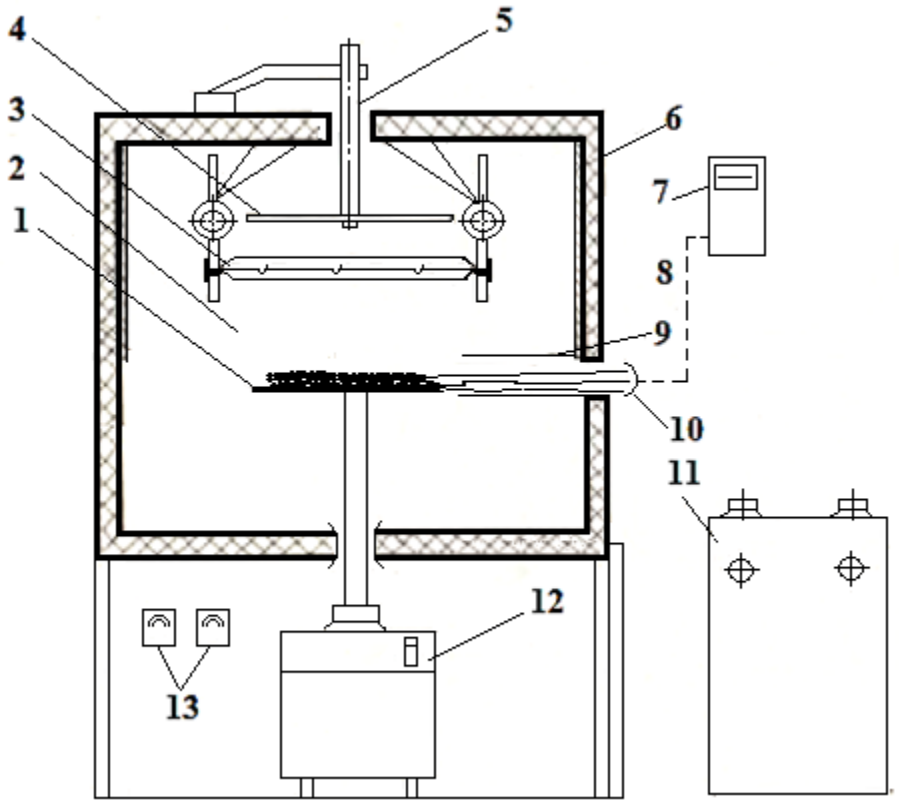

Fig. 1. Laboratory setup diagram

A study of the heating of a sample of apricot kernel petals was carried out by measuring the temperature at three points (depth 1.5 mm; 3.0 mm; 4.5 mm) along the height of the sample. Standard thermocouples with a junction diameter of 0.2 mm and with heat-resistant insulation were used as temperature sensors. The latter are connected to a UNI-T UT39C + digital multimeter with limit of measurement from -40°C to + 1000°C, the error is ± 1.0% ± 4 counting units.

After the end of the IR heat treatment process, the location of the thermocouples along the height of the petals is measured again.

It should be noted that when the thermocouples are embedded in the hinge, accurate fixation at a given depth is not guaranteed. Therefore, in order to ensure the reliability of experimental studies of the process, the number of experiments is increased.

The material with a thickness of 6÷7 mm is heat-treated using KGT 220-1000 infrared emitters, emitting beams with a maximum wavelength of 1.1 microns. The choice of the wavelength value of 1.1 μm is due to the fact that the kernel of stone fruit (apricot) in the wavelength range of 0.7÷1.2 μm has the highest transmission capacity, and therefore,

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for effective heating over the entire layer thickness, it is advisable to choose such an IR radiation generator that has the maximum radiation intensity in the range of 0.7÷1.2 μm [7].

Figure 2. shows the temperature field inside the layer of petals of kernels of apricot kernels under continuous IR irradiation. The figure shows the temperature at a depth of 1.5 mm during the entire irradiation exceeds the temperature of the lower layers and in three minutes of irradiation reaches up to 78°C, while the question arises about the expediency of using intermittent irradiation. This avoids overheating of the material, which is very important for maintaining the quality of biologically active substances.

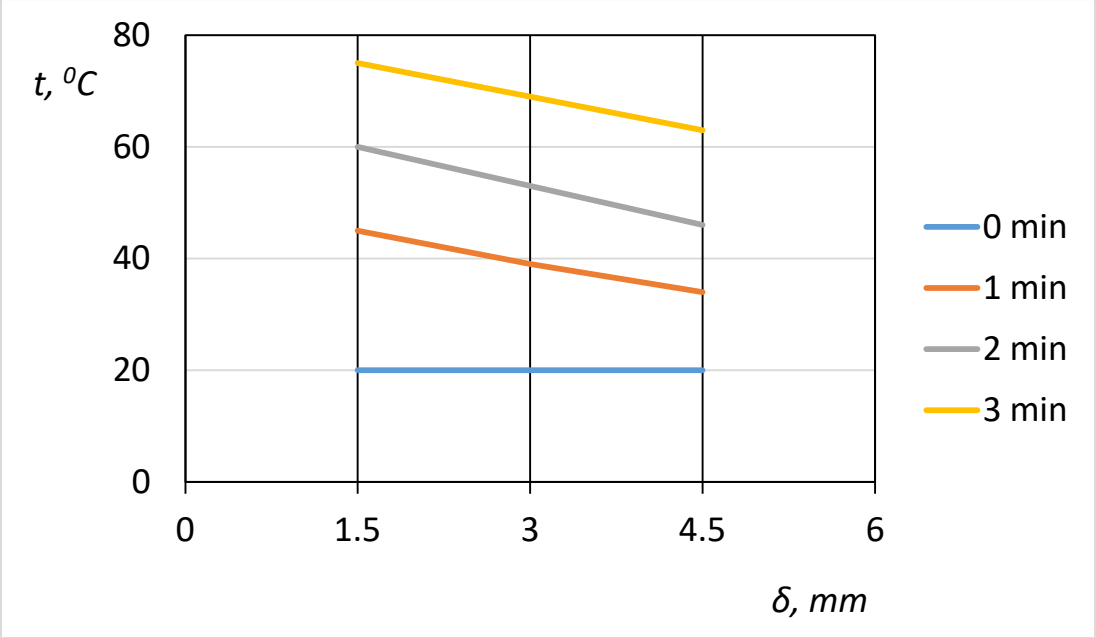

Fig. 2. The change of the temperature in different layers of petals of apricot kernels

In the intermittent mode of IR irradiation of the material, the situation looks different (Fig. 3). The duration of the first irradiation is 60 s, the temperature of the material will reach up to 480C. The time of the first «nap» is 45s, the temperature will drop to 400C, the second irradiation will last 30 s, after which the temperature will reach 520C, the second «nap» is given for 50 s and the temperature will drop to 420C. After that, the third irradiation is given for 30 s, while the temperature will reach 550C. The moisture content of the material will decrease from 10% to 7%.

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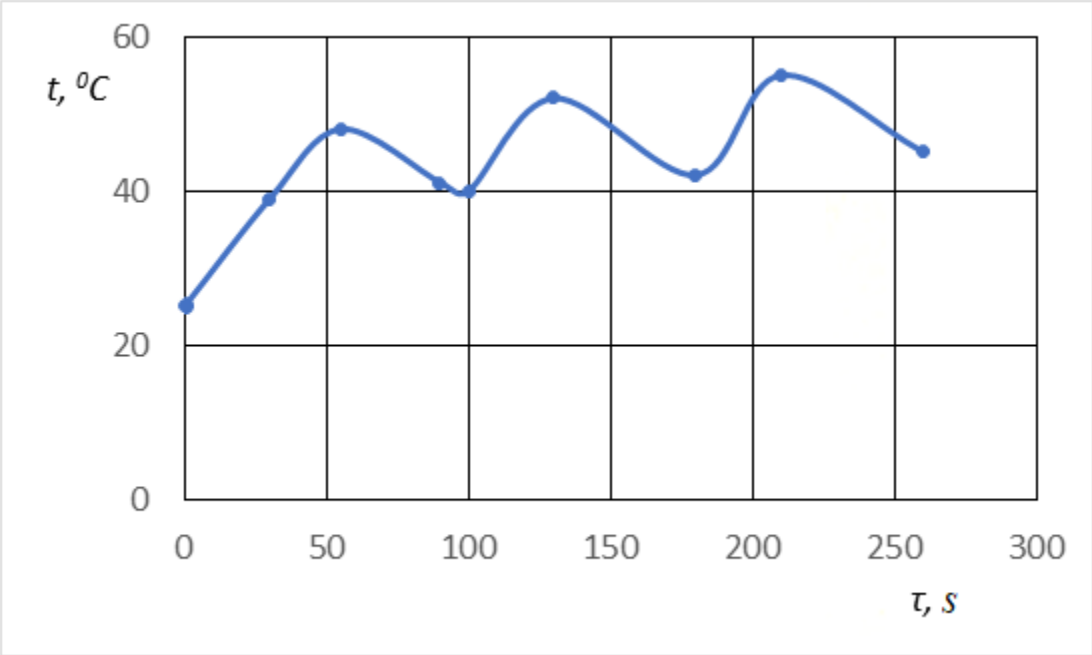

Fig. 3. Change in the temperature of the petal of the kernels of apricot kernels during intermittent IR irradiation

To determine the level of exposure to intermittent IR irradiation, the cell structure using an electron microscope before and after IR treatment of the petals of apricot kernel kernels was studied. Figure 4 shows an electron microscopic photograph, obtained by the method [8, 9], of the petals of the kernels of apricot kernels before and after IR treatment. As can be seen in the photograph (Fig. 4b), the cell walls are destroyed, the intercellular substances have changed only their shape. Lipid inclusions are enlarged due to phase transformation.

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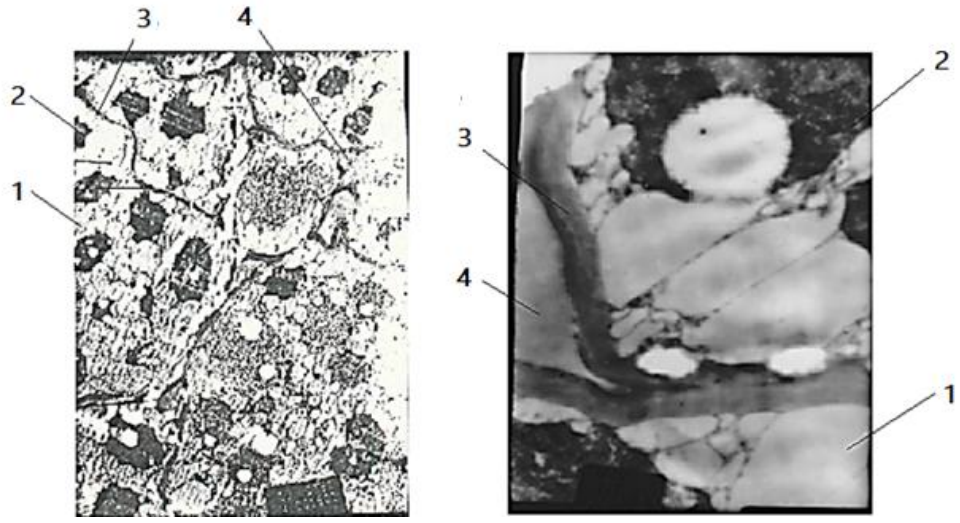
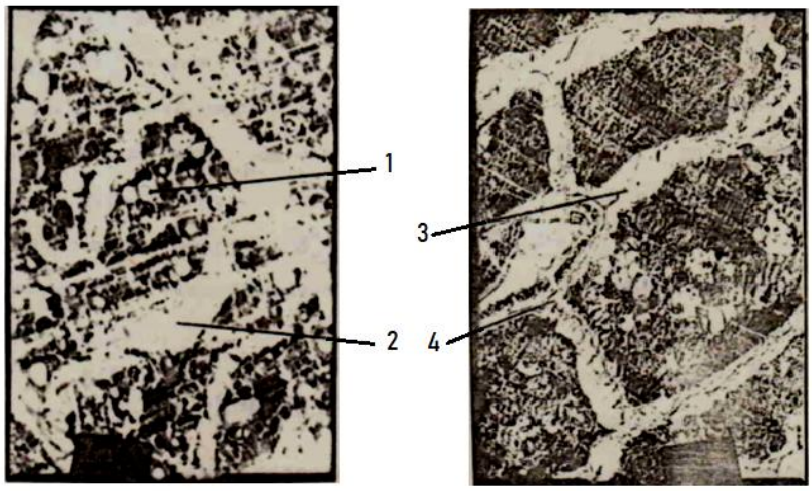


40*10^3 times enlargement 103*10^3 times enlargement

Fig. 4 a. Electron microscopic photographs of the apricot kernel petal before processing

1-lipid; 2-protein; 3-cell wall; 4-intercellular substances.



40*10^3 times enlargement

Figure: 4 b. Electron microscopic photographs of the petal of the kernel of apricot kernels after processing 1- enlarged lipid; 2-protein; 3- destroyed cell wall; 4-intercellular substances; 5-protein-enzyme at the cell wall; 6- soluble sugars.

CONCLUSIONS

With intermittent infrared heat treatment, the temperature of the material does not rise

above 580C, which contributes to the preservation of all useful substances in the composition of the material: lipids, proteins, vitamins, etc. The moisture content of the material will be within 7%. The penetration of infrared rays deep into the material creates conditions for the destruction of the cell walls of plant material. All this creates favorable opportunities for obtaining an increase in the yield of extracts with a high content of useful substances during direct extraction using ethanol or carbon dioxide in the sub- and supercritical state as a solvent.

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