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RESEARCHING THE PROCESS OF HEAT TREATMENT OF APRICOT KERNELS BASED ON THE DEVELOPMENT OF A MULTIFACTORIAL EXPERIMENTAL PLAN.

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Abstract. This article studies and develops the design of a two-factor experiment that allows you to conduct research work at an accelerated pace and ensure decision-making that is close to optimal.The experiments are aimed at developing a new method of heat treatment in the production of salted pits from valuable apricot waste. A planning matrix for full factorial experiments has been developed.Based on the processing of experimental results, a model has obtained that has some optimal properties.

Keywords: processing, seeds, apricot, planning, experiment, full factorial, variation, model, matrix, heat treatment, microwave processing, factor.

Introduction. Apricot stone is small, smooth or slightly rough, with a strong hard shell, about 1-2 mm thick. It is rather difficult to split it, and this is what often stops homemakers. However, there are many ways to deal with this "stubborn nut". The main feature when splitting is that the core inside is not damaged, does not turn into porridge and does not mix with small pieces of the shell. Ideal is such a core, which has not damaged brown skin, which protects the core from drying out and losing its taste. Nevertheless, apricot kernels had recommended would put in apricot jam, consumed dried and salted, used in folk medicine to treat respiratory diseases and even cancer [1].

Traditional research methods are associated with experiments that require large expenditures, effort and money, because. "passive" - based on the alternate variation of individual independent variables in conditions when the rest tend to remain unchanged. Experiments, as a rule, are multifactorial and are associated with optimizing the quality of materials, finding optimal conditions for conducting technological processes, developing the most rational equipment designs, etc. The systems that serve as the object of such research are very often so complex that they cannot theoretically studied in a reasonable time.Therefore, despite the significant amount of research work performed, due to the lack of a real opportunity to sufficiently fully study a significant number of research objects, as a result, many decisions have made based on random information, and therefore are far from optimal. Based on the above, there is a need to find a way that allows you to conduct research work at an accelerated pace and ensure decision-making that is close to optimal.Our experiments are aimed at developing a new method for the production of salted apricot pits from valuable apricot waste [2].

The purpose of the experiment is to collect the necessary statistical information about the object to establish quantitative and qualitative relationships in mass phenomena and build stochastic models that reflect the relationship between various factors and properties of the object.The experiment is carried out in order to find the conditions for the flow of processes that provide the optimal value of the selected parameter (extremely problem), and to construct an interpolation formula for predicting the values of the studied parameter, which depends on a number of factors (interpolation problem).A full factorial experiment (FFE) is an experiment that implements all possible non-repeating combinations of levels of independent controlled factors, each of which varies at two levels. The number of these combinations N = 2n determines the type of PFE. The levels of factors represent the boundaries of the object under study for a given technological parameter.In our case, the object under study is heat treatment, therefore, during heat treatment, the structural-mechanical, physico-chemical and organoleptic properties of the product change, which determine the degree of readiness or semi-readiness of the product. Heating causes changes in proteins, fats, carbohydrates, vitamins and minerals in the product [3].

Materials and methods. The main methods of heat treatment of food products are boiling and frying, used both as independent processes and in various combinations. To implement these techniques in thermal equipment, various methods of heating products are used: surface, volumetric, combined. With all methods of heating food products, external heat transfer is accompanied by mass transfer, as a result of which part of the moisture of the products passes into the external environment.Almost all food products are capillary-porous bodies, in the capillaries of which the liquid hasretained by surface tension forces. When the products are heated, this liquid begins to migrate (move) from the heated layers to the colder ones.Apricot has considered a delicious fruit and grown in various parts of the world;it is also famous due to its potential nutritional and chemical composition [4]. Identificationfeatures of apricot seed and fruithad represented in Figure 1

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Figure 1. Apricot kernel seed and fruit identification

When frying products, moisture from the surface layers partially evaporates, and partially moves deeper to colder areas, which leads to the formation of a dry crust, in which the thermal decomposition of organic substances occurs (at a temperature of more than 100 °C).

The faster the surface heats up, the more intense the transfer of heat and moisture and the faster the formation of a surface crust.Surface heating of the product has carried out by thermal conduction and convection when heat has supplied to the center of the product through its outer surface. At the same time, the heating of the central part of the product and bringing it to culinary readiness occur mainly due to thermal conductivity.The intensity of heat transfer depends on the geometric shape, dimensions and physical parameters of the processed product, the mode of movement (product and medium), temperature and physical parameters of the heating medium. The duration of the heat treatment process during surface heating is due to the low thermal conductivity of most food products.The volumetric method of heat supply to the processed product is implemented in devices with infrared (IR), microwave (MW), electro contact (EC) and induction heating [5, 6].

Infrared radiation has converted in the volume of the processed product into heat without direct contact between the source of IR energy (generator) and the product itself. The carriers of IR energy are electromagnetic oscillations of an alternating electromagnetic field that occur in the product.

Infrared energy in the processed product had formed during the transition of electrons from one energy level to another, as well as during the vibrational and rotational movements of atoms and molecules. Transitions of electrons, the movement of atoms and molecules occur at any temperature, but with its increase, the intensity of infrared radiation increases.Microwave heating of food products carried out by converting the energy of an alternating electromagnetic field of ultrahigh frequency into thermal energy generated throughout the volume of the product. The microwave field is able to penetrate into the processed product to a considerable depth and carry out its volumetric heating, regardless of thermal conductivity, and used for products with different moisture content [7]. The high speed and high efficiency of heating make it one of the most efficient ways to bring food to culinary readiness.Microwave heating called dielectric heating because most food products are poor conductors of electric current (dielectrics). Its other names - microwave, volume - emphasize the short wavelength of the electromagnetic field and the essence of the heat treatment of the product, which occurs throughout the volume.The effect of heating food products in a microwave field is associated with their dielectric properties, which determined by the behavior of bound charges in such a field. The displacement of bound charges under the action of an external electric field has called polarization [8]. The greatest energy consumption of the external electric field is associated with dipole polarization, which occurs because of the action of an electromagnetic field on polar molecules that have their own dipole moment.

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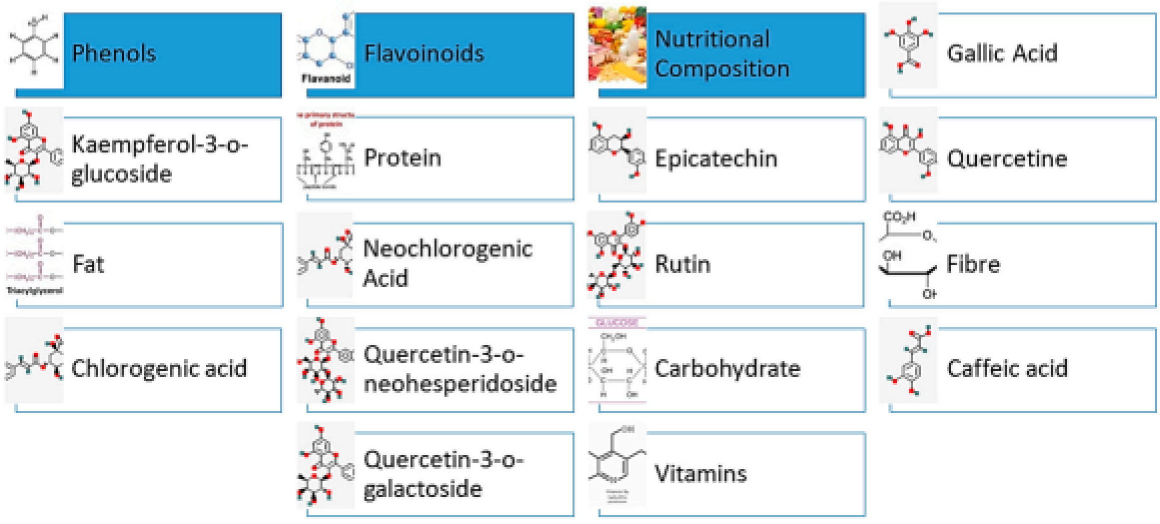

Figure 2. Classification of different bioactive compounds of apricot kernel

An example of a polar molecule is the water molecule. In the absence of an external field, the dipole moments of molecules have arbitrary directions.In an electric field, forces act on polar molecules, tending to rotate them in such a way that the dipole moments of the molecules coincide. The polarization of a dielectric is that its dipoles are set in the direction of the electric field.Electro contact heating provides a rapid increase in the temperature of the product throughout the volume to the required value in 15-60 seconds, and due to the passage of an electric current through it [9]. The method has used in the food industry for heating dough pieces when baking bread, when blanching meat products. Products subjected to heating are located between electrical contacts. Gaps between the surface of the product and the contacts can cause the surface to "burn".

Discussion. Induction heating is used in modern induction household cookers and catering establishments. Induction heating of conductive materials, which include most metals for cookware, occurs when they have placed in an external alternating magnetic field created by an inductor. An inductor installed under the plate flooring creates eddy currents that close in the volume of the dishes.The product has processed in a special metal plate dish, which heats up almost instantly due to the directional action of the electromagnetic field. At the same time, heat loss to the environment has reduced to a minimum, which reduces energy costs for cooking compared to a conventional electric stove by 40%. In such thermal apparatus, the flooring of the plate, as a rule, is made of ceramic materials and remains practically cold during heat treatment [10].Combined methods of heating food products are sequential or parallel heating of products by several of the known methods in order to reduce the heat treatment time, improve the quality of the final product and the efficiency of the technological process. Microwave processing of apricot pits shows many promising advantages over conventional heating technologies, such as improved product quality, reduced process control time, energy and energy cost savings due to higher efficiency, reduced environmental pollution, lower maintenance costs. Equipment maintenance and higher installation flexibility. In this case, microwave heating has understood as a process in which energy with a frequency of MHz to 300 GHz penetrates the heated material as an electromagnetic wave with a wavelength in the range of 1 m to 1 mm, and then it has converted into heat.Thanks to thermal radiation and convective heat exchange, their energy is transferred to the surface of the apricot kernels and from there it moves to the inside in order to ensure through heating of the material. The thermal conductivity, adsorption and specific heat capacity of the material mainly determine the heating process [11]. Sensitive materials under certain circumstances do not allow high temperatures, and if the material still has poor thermal conductivity, then a long process is inevitable in this case, therefore, when manufacturing certain products using traditional heating technologies, limits are set.In order to get around these boundaries, it is not necessary to rewrite physics anew, but simply to give more attention to “high-frequency or radar technology”. It retains the potential of an extremely energy efficient heating method, so that a variety of research papers have already been created on the study of microwave heating [12,13].

Results. We introduce the concept of lower $X_k^n$and uper X_k^v factor level X_kIn our case, the first factor is the power of the heat flux X_1, the second factor is the duration of the product processing X_2. The levels of variation of the two factors are as follows:

Upper level (+):

- heat flow power 1.2 kW;
- duration of product processing 3 min.

Lower level (-):
- flow power 0.6 kW;
- duration of product processing 5 min.
Factors were coded (Table 1.)

Table 1. Factor coding

Factors	Upper level X^v	Lower level X^n	Center	Interval variationsλ	Dependence of the coded variable on the natural one
x_1	1,2	0,6	0,9	0,3	$(x_1$-0,9)/0,3
x_2	3	5	4	1	$(x_2$-4)/1

Since we have two influencing factors and they change at two levels, we get the planning of experiments for 22. Thus, it is necessary to conduct 4 experiments. For the example under consideration, the coding of factors means the transition from a coordinate system in natural units to a coordinate system in coded form. Eachpointofthefactorspace(-1; -1), (+1;-1), (-1; +1), (+1; +1) it is experience in research.

In the general case, an experiment in which all possible combinations of factor levels had implemented is a full factorial experiment (FFE). If each of the n factors varies at two levels, then a PFE of type second already obtained [14]. Recording all combinations of factors in coded form forms a planning matrix. Table 2 is a planning matrix for two factors at two levels.

Table 2. Experiment Design Matrix for 2^2

№ Experiment	Factors		Interaction effects of factors	Результаты опытов			Average results
	x_1	x_2	x_1x_2	y_1	y_2	y_3	$\bar{y}_j$
1	-1	-1	1	19,2	19	18,6	18,933
2	1	-1	-1	20	20,3	20,2	20,167
3	-1	1	-1	21,5	21,2	21	21,233
4	1	1	1	19,9	20,2	20	20,033

Sample mean of results$\bar{y}_j$for each experiment we calculate according to the formula and write it down in table 2:

$$\bar{\boldsymbol{y}}_{\boldsymbol{j}} = \frac{\mathbf{1}}{\boldsymbol{m}} \sum_{\boldsymbol{i}=\mathbf{1}}^{\boldsymbol{m}} \boldsymbol{y}_{\boldsymbol{ji}}$$

wherem- number of experiments (observations) in each experiment;

y_{ji}– the result of a separate i-th observation in the j-th experiment

To establish the dependence of the output value on the input values, it is necessary to compose a regression equation for the output value y with respect to two factors. To do this, we calculate the regression equation in the future. Since the PFE2^k planning matrix must meet certain requirements, the formulas that determine the coefficients of the regression equation are quite simple:

$$b_0 = \frac{1}{n} \sum_{j=1}^{n} \bar{y}_j$$

$$b_1 = \frac{1}{n} \sum_{j=1}^{n} x_{ji}\,, \bar{y}_j\,, i = \overline{1,k}$$

$$b_{r,p} = \frac{1}{n} \sum_{j=1}^{n} x_{jr} x_{jp} \bar{y}_j\,, r < p, r = \overline{1,k}, p = \overline{1,k}$$

And so on if other interactions have taken into account.

The obtained coefficients check for significance. We determine the significance of these coefficients:

Finding the reproducibility variance $S_j$according to the formula:

$S^2_{\{j\}} = \frac{\sum_1^N \sum_1^n (y_{nj} - \overline{y_j})^2}{N(n-1)}$,

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whereN – the number of experiments;
n – number of repeated observations in each experiment.
The regression equation in our case has the following form:

$$y = b_0 + b_2 - b_{1,2}$$
$$y = 20{,}0917 + 0{,}5417b_2 - 0{,}6083b_{1,2}$$

Let us check the resulting regression equation for adequacy by the Fisher criterion. Since the reproducibility dispersion has found, to determine the calculated value of the criterion$F_{calculation}$it is necessary to calculate the residual variance$S^2_{residual}$.

To do this, we find the values of the parameter under study according to the obtained regression equation$\bar{y}_j(j = 1, \dots, 4)$, substituting +1 or -1 instead of$b_i$according to experiment number j:

$$y = b_0 + b_2 - b_{1,2}$$

According to the table of critical points of the Fisher distribution at the significance level α=0,05$F_{table} = 5{,}32$.

Because$F_{calculation} = 0{,}02 < F_{table} = 5{,}32$, then the regression equation is adequate.

This means that the resulting model adequately describes the process.

Using the equations obtained, we plot the dependence of the heat treatment of apricot pits on the influencing factors of the power of the heat flux of the microwave oven and the duration of processing of apricot pits using the MatLab program (Figure 3).

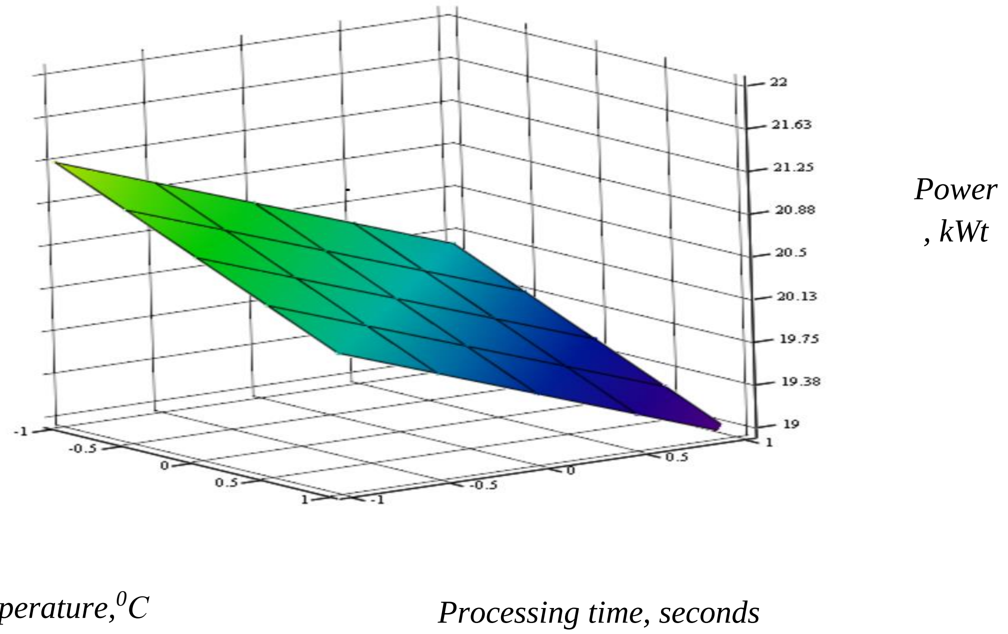

Figure 3. Dependence of the thermal treatment of apricot kernels on the influencing factors of the power of the heat flux of the microwave oven and the duration of processing of apricot kernels

Conclusion. The graph shows that with an increase in the power of the heat flux of the microwave oven, the duration of processing of apricot pits decreases. In a saline solution, moisture absorption increases. According to Figure 1, the rational values of the influencing factors are temperature t=47^{0}Cand the duration of processing in the microwave oven is 20 - 40 seconds.

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