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Getting Melon Oil by Co2-Extraction

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ANNOTATION

Uzbekistan is a major producer of melons, including melons. The volume of melon production in 2022 in Uzbekistan will be about 1.3 million tons. The yield of melon seeds is 0.6-2.0% of the fruit mass. Melon seed oil has a pleasant smell, good taste, light yellow color. The oil yield of Central Asian varieties is 51÷54% per kernel. Currently, oil is extracted in Uzbekistan by the so-called "cold" method of pressing seeds. But with this method, half of the oil in the seeds is extracted. An extraction method is used to completely extract the oil from the seeds. One such method is extraction with supercritical carbon dioxide. In the present study, the process of extracting oil from the seeds of a local variety of melon by extraction with supercritical carbon dioxide is considered. The influencing factors on the process were determined and, by means of a full-factorial experiment, the regularity of the process output (residual oil content of melon seed meal) on the temperature and pressure of the extracting was determined. Based on this regularity, rational values of the influencing factors are determined, under which the residual oil content of the meal will be minimal.

KEYWORDS: *melon; seeds; supercritical carbon dioxide; oil; extraction; temperature; pressure; extract; full factorial experiment.*

Introduction. A huge number of varieties of melon (lat. Cucumis melo) sprout in Uzbekistan. For example, Okurug, Asate 3806, Borikalla, Koktinna, Kokcha, Kizilurug, local yellow kandalak, Obi novvot, Shakarpalak, Gurlan, etc. According to [2] the volume of melon production in 2022 in Uzbekistan will be about 1.3 million tons. The yield of melon seeds is 0.6-2.0% of the fruit mass [2], which is 7.8-26.0 thousand tons per year. Of these, 10-12% is processed through the extraction of oil by "cold" pressing.

Melon seeds are yellow or cream-colored, elongated-elliptical, 0.92÷1.60 cm long and 0.41÷0.69 cm wide. Seeds contain about 40% of shells and about 60% of the kernel, are rich in proteins and oil [2].

Chemical composition of seeds, % in terms of dry matter: water - 6.0÷6.2; lipids – 25.0÷26.5; protein (N×6.25) – 22.5÷25.5; starch and soluble sugars - 10 ÷ 11; pentosans - up to 8.0; cellulose - 20.0÷21.4; ash - 25.5÷30.0. The kernel contains up to 50% oil, the husk - 0.5÷0.6%. They also contain galactan, glucose, gums, and resins. The seed protein consists of glutens and globulin [2]. The content of protein nitrogen in melon seeds is 4.75÷5.89%. About half of the extractive nitrogen is non-protein nitrogen and 15% is accounted for by amino acids (cysteine, lysine, histidine, arginine, tryptophan), 50% consisting of arginine [3]. It was confirmed in [4] that in the studied melon seed protein samples, glutamic acid, aspartic acid, and arginine account for more than a third of the total amino acid content. Melon seed oil is not inferior in taste to the best varieties of Provence. The oil has a pleasant smell, good taste, light yellow color. The oil yield of Central Asian varieties is 51÷54% per kernel. Melon oil is characterized by a high (123-183 mg) iodine number and a low (1.77÷3.77 mg) acid value [4]. Researchers Petkova Z. and Antova G. studied the chemical composition of seeds of three melon varieties from Bulgaria [5]. The chemical composition values were as follows: fat content from 41.6 to 44.5%, proteins from 34.4 to 39.8%, crude fiber from 4.5 to 8.5%, carbohydrates from 8.2 to 12.7%, soluble sugars from 3.7 to 4.2% and minerals from 4.6 to 5.1% . The content of sterols, phospholipids and tocopherols in oils was 0.7÷1.7% and 435÷828 mg/kg, respectively. The main fatty acid in lipids was linoleic (51.1÷58.5%) followed by oleic acid (24.8÷25.6%).

For the production of high-quality oil with a high content of vitamins and microelements, which meets the requirements of pharmacopoeia and cosmetology, a low oil extraction temperature is required, which must be maintained throughout the entire technological process at a level of approximately 60÷70^{0}C.

There are various options for extraction methods for extracting vegetable oils: extraction with hydrocarbon solvents, alcohols, acetone, ether, oils and their mixtures with other organic solvents, liquefied gases, etc. For each type of raw material, many types of extraction technology can be used to ensure a high yield of target products. The final choice is determined by the given quality of the resulting drug (composition, consistency), the level of production safety, the complexity of the hardware design of the process, and economic considerations. Now 90% of all supercritical fluid technologies are focused on supercritical carbon dioxide (SC-CO_2). Its widespread use is associated with a number of properties that make carbon dioxide a unique solvent, namely [6,7,8,9,10,11]: critical temperature close to room temperature (31.3^{0}C) and low critical pressure (7.39 MPa); environmental safety and extremely low toxicity, which makes it indispensable in the food and pharmaceutical industries; explosion and fire safety; low cost and general availability; at atmospheric pressure is a gas, which ensures complete separation of the extract by depressurization.

Features of the structure of vegetable raw materials in our region - fruit stones, seeds of grapes, pumpkins, melons, etc., suggest the development of technological modes of extraction using liquid and supercritical carbon dioxide, the kinetics and dynamics of the extraction process, determining the effect of the extraction process on the yield and quality of the resulting product [12].

Based on this, the purpose of this study is to experimentally identify the dependence of the yield of melon seed oil on the influencing factors during CO_2 extraction.

The objectives of the study are: to determine the boundary values of the factors influencing the CO_2-extraction process, to develop an experimental plan, to obtain a statistical and mathematical model of the process.

Materials and methods. Seeds of local melon varieties “Obi-novvot were used for research. Для обеспечения оптимальной внешней структуры экстрагируемого материала, его подают на парные плющильные вальцы. Получающийся лепесток должен характеризоваться следующими показателями: толщина лепестка 0,3÷0,4 мм; проход через одно-миллиметровое сито 5÷6 %. CO_2 was used as an extractant in the supercritical state.

The study of the process of extracting ingredients from local plant materials with supercritical carbon dioxide was carried out on a laboratory unit [13,14].

The laboratory installation consists of the following main elements: a high-pressure extractor with a cassette for placing a sample of plant raw materials, an extractant supply system, a product collection system, a condensation system, a heat pump system, a system of instrumentation and automation.

By changing the temperature or pressure of the fluid, one can change its properties in a wide range. Thus, it is possible to obtain a fluid whose properties are close to either a liquid or a gas. The dissolving power of the fluid increases with increasing density (at constant temperature). Since the density increases with increasing pressure, changing the pressure can affect the dissolving power of the fluid (at a constant temperature). In the case of temperature, the dependence of fluid properties is somewhat more complicated - at a constant density, the dissolving power of the fluid also increases, however, near the critical point, a slight increase in temperature can lead to a sharp drop in density, and, accordingly, dissolving power. Therefore, the pressure and temperature of the extractant (SC-CO2) were chosen as influencing factors. The limits of factor variation are determined on the basis of preliminary experiments. The levels of variation of the two factors are as follows:

Upper level (+):

- pressure 10 MPa,
- Temperature 33^0C.

Lower level (-):

- pressure 8 MPa,
- Temperature 31^0C.

Conducted coding factors (table 1)

Since we have two influencing factors, and they change at two levels, we get the planning of experiments for 2^2. Thus, it is necessary to conduct 4 experiments.

Table1. Coding factors

Factors	Lower level x^+	Upper level x^-	Center	Interval variations λ	Dependence of the coded variable on the natural one
x_1	10	8	9	1	$(z_1-9)/1$
x_2	33	31	32	1	$(z_2-32)/33$

Results. Full Factor Experiment Planning Matrix $N=2^2$ and the obtained average results of the experiments are given in table2.

Table 2 Experiment plan matrix for 2^2

№ experiment	Factors		Interaction effects of factors	Experimental results			Average results
	x_1	x_2	x_1x_2	y_1	y_2	y_3	
1	-1	-1	1	4,2	4	3,6	3,933
2	1	-1	-1	3,2	3,0	3,5	3,233
3	-1	1	-1	3,5	3,7	3,3	3,500
4	1	1	1	2,8	3,2	3	3,000
						$\Sigma\bar{y}_j$	13,666

Regression coefficients are calculated using the least squares method. The calculation results are given in Table 3.

Table 3.The results of calculating the values of regression coefficients

Coefficients	b_0	b_1	b_2	b_{12}
Values	3.4167	-0.3000	-0.1667	0.0500

Discussion. We determine the significance of these coefficients.

From Student's distribution tables [15] for the number of degrees of freedom $n(m-1)=4\cdot 2=8$ at significance level α = 0,05 discover $t_{кр.}$= 1.86.

Estimated value of Student's criterion $|b_j|= t_{кр.}\cdot S_к$ = 1.86·0.0860=0.15996. Comparing the obtained value of 0.15996 with the coefficients of the regression equation, we find that all coefficients except b_{12} are greater in absolute value |b_j |. Therefore, all coefficients except b_{12} are significant. Thus, this coefficient is excluded from the regression equation. Уравнение регрессии имеет вид:

$$y = 3.8833 - 3.2833x_1 - 3.5500x_2 \quad (1)$$

The adequacy of the obtained regression equation was checked using the Fisher criterion. For our case $S_0^2 = 0{,}0300$. At the level of significance α = 0.05 and degrees of freedom $k_1=n-r=4-3=1$ и $k_2=n(m-1)=8$; $F_m=5.32$. Estimated value of the Fisher criterion $F_p=0.51$.

This means that the resulting model (1) adequately describes the process. Let us transform the equation (1) from the coded values of the influencing factors to natural values, substituting instead of x_i their expressions through z_i, which are calculated by the formulas given in Table 1. Having carried out arithmetic operations, we obtain the equation in natural values:

$$Y=65.08-3.28z_1-0.71z_2 \qquad (2)$$

According to the obtained equation (2), we plot the dependence of the residual oil content of melon seeds (meal) on the influencing factors of pressure and temperature on the MatCAD platform (Fig. 1).

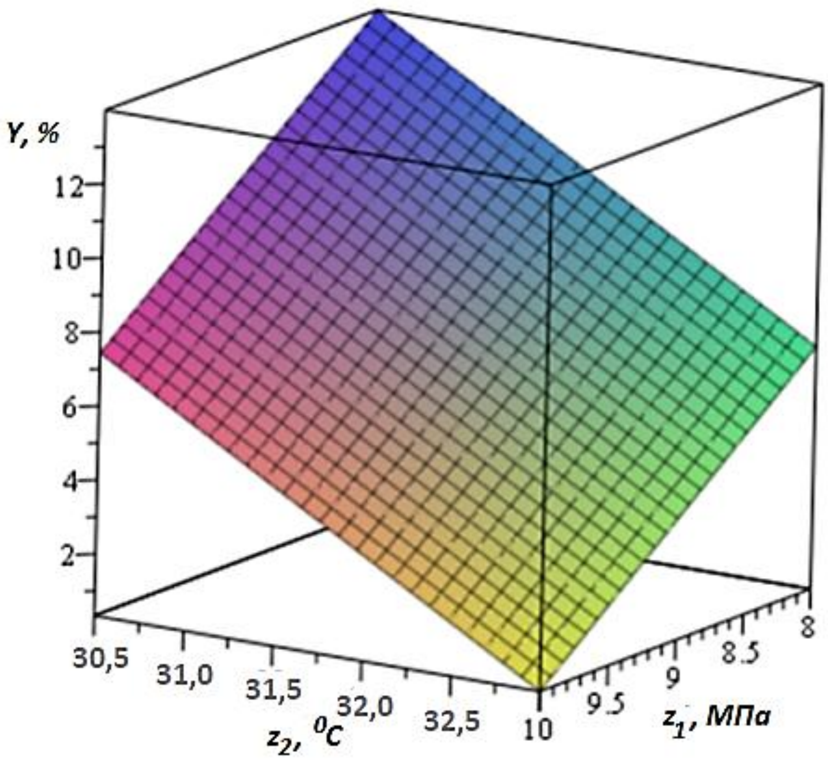

Fig.1. Dependence of the residual oil content of melon seeds (meal) Y on the influencing factors of pressure z_1 and temperature z_2

Conclusion. The graph shows that with an increase in pressure and temperature, the oil content of the meal decreases. According to Fig.1, the rational values of the influencing factors are pressure P=9.8 MPa, temperature t=31.5 ^{0}C. With this extraction mode, the residual oil content of the meal is 2.1%.

The quality indicators of the obtained melon oil were checked in an accredited complex of the testing laboratory of the Bukhara Center of the State Sanitary and Epidemiological Supervision, which revealed that the given samples of vegetable oils meet the sanitary requirements of the Republic of Uzbekistan.

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