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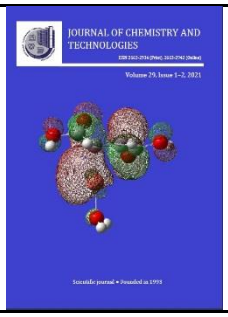

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A STUDY OF THE INFLUENCE OF CALCIUM ACETATE ON THE PROCESS OF SUNFLOWER OIL DEGUMMING

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Abstract

The stage of degumming of vegetable oils is carried out in order to extract polar lipids – phospholipids. The efficiency of this stage depends not only on the low final content of phospholipids in the refined oil, but also on the safety of the used degumming agents, speed, easiness of degumming and low cost of the process. The process of degumming of sunflower oil in the presence of a new degumming agent - calcium acetate has been studied. Calcium acetate (food additive E 263) is a safe substance that is completely absorbed by the human body and does not have a negative impact on the environment. Rational conditions for degumming to obtain the oil with a phospholipid content of < 0.05% have been established. Rational conditions for degumming in the presence of calcium acetate have been determined. The main indicators of the quality of refined oil and lecithin obtained as a result of degumming have been investigated. They comply with the requirements of the current regulatory documents. One of the disadvantages of sunflower lecithin is its ability to be changed from a liquid to a plastic state, namely, , to increase the viscosity during storage. The double technological effect of using calcium acetate has been proven – it is an effective degumming agent and an additive, is able to significantly reduce the viscosity of lecithins, obtained at the hydration stage, to the values at which they do not form plastic modification.

Keywords: sunflower oil; degumming; lecithin; phosphatide concentrate; phospholipid content; lecithin viscosity; calcium acetate.

ДОСЛІДЖЕННЯ ВПЛИВУ АЦЕТАТУ КАЛЬЦІЮ НА ПРОЦЕС ГІДРАТУВАННЯ СОНЯШНИКОВОЇ ОЛІЇ

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Антоація

Стадія гідратування рослинних олій проводиться з метою вилучення полярних ліпідів – фосфоліпідів. Ефективність проведення цієї стадії полягає не лише в низькому остаточному вмісті фосфоліпідів у гідратованій олії, а й у безпечності застосованих гідратуючих агентів, швидкості, простоті проведення гідратування та низькій вартості процесу. Досліджено процес гідратування соняшникової олії в присутності нового гідратуючого агенту – ацетату кальцію. Ацетат кальцію (харчова добавка Е 263) є безпечною речовиною, що повністю засвоюється організмом людини та не чинить негативного впливу на довкілля. Встановлено раціональні умови проведення гідратування з метою одержання олії зі вмістом фосфоліпідів < 0.05 %, а саме: кількість ацетату кальцію – 0.01 %;тривалість гідратування – 10 хв; кількість води – 1 %. Визначено раціональні умови проведення гідратування в присутності ацетату кальцію. Досліджено основні показники якості гідратованої олії та лецитину, одержаного в результаті гідратування. Вони відповідають вимогам діючих нормативних документів. Одним з недоліків лецитину соняшнику є його здатність переходити з рідкого стану до пластичного, тобто підвищувати в'язкість в процесі зберігання. Доведений подвійний технологічний ефект використання ацетату кальцію – як ефективного гідратаційного агенту та добавки, що суттєво знижує в'язкість лецитинів (які одержують на стадії гідратування) до значень, за яких вони не утворюють пластичної модифікації.

Ключові слова: соняшникова олія; гідратування; лецитин; фосфатидний концентрат; вміст фосфоліпідів; в'язкість лецитину; ацетат кальцію.

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ИССЛЕДОВАНИЕ ВЛИЯНИЯ АЦЕТАТА КАЛЬЦИЯ НА ПРОЦЕСС ГИДРАТАЦИИ ПОДСОЛНЕЧНОГО МАСЛА

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Аннотация

Стадия гидратации растительных масел проводится с целью извлечения полярных липидов – фосфолипидов. Эффективность проведения этой стадии заключается не только в низком конечном содержании фосфолипидов в гидратированном масле, но и в безопасности применяемых гидратирующих агентов, скорости, простоте проведения гидратации и низкой стоимости процесса. Исследован процесс гидратации подсолнечного масла в присутствии нового гидратирующего агента – ацетата кальция. Ацетат кальция (пищевая добавка Е 263) является безопасным веществом, которое полностью усваивается организмом человека и не оказывает негативного влияния на окружающую среду. Установлены рациональные условия проведения гидратации с целью получения масла с содержанием фосфолипидов < 0.05%. Определены рациональные условия проведения гидратации в присутствии ацетата кальция. Исследованы основные показатели качества гидратированного масла и лецитина, полученного в результате гидратации. Они соответствуют требованиям действующих нормативных документов. Одним из недостатков лецитина подсолнечника является его способность переходить из жидкого состояния в пластическое, то есть повышать вязкость в процессе хранения. Доказан двойной технологический эффект использования ацетата кальция – как эффективного гидратирующего агента и как добавки, способной существенно снижать вязкость лецитинов, полученных на стадии гидратации, до значений, при которых они не образуют пластической модификации.

Ключевые слова: подсолнечное масло; гидратация; лецитин; фосфатидный концентрат; содержание фосфолипидов; вязкость лецитина; ацетат кальция.

Introduction

The first of the stages of refining vegetable oils - degumming, is carried out in order to extract phospholipids from oils. Phospholipids are physiologically active substances: they are essential for the growth, development and functioning of all somatic cells of the body, they are antioxidants and take part in the work of the nervous system. Phospholipids provide substrates for intercellular communication, which allowes to regulate hemostasis, immunity, thrombosis, and are essential for treatment of cardiovascular diseases (Важливі при лікуванні цих захворювань, чи беруть учать у утворенні захворювань? Я обрала при лікуванні, проте варто перевірити та виправити якщо це невірно). Also, phospholipids are an integral part of cell membranes – the liver consists of 80 % phospholipids, the brain – of 60 %, etc. [1; 2]. Despite the many positive physiological functions of phospholipids, they are removed from the composition of oils due to the negative effect that they have at the stage of refining. Thus, neutralization, adsorptive cleaning, deodorization, the main stages of obtaining refined oils, are impossible to carry out qualitatively in the presence of significant amounts of phospholipids in oils [3]. The purpose of degumming is the most complete removal of phospholipids, as well as a reduction of the content of metals with variable valence, removal of mechanical impurities, etc. How does the degumming process take place? When water is added to the oil, phospholipids are gradually concentrating on the surface of water droplets, and their hydrophilic part is immersed [4] (Fig. 1, position on the right – a part of the phosphoester group with an attached nitrogen-containing fragment and glycerol skeleton, respectively) inside the droplets (Fig. 1, position on the left - two fragments of fatty acids), the hydrophobic part is in the oil.

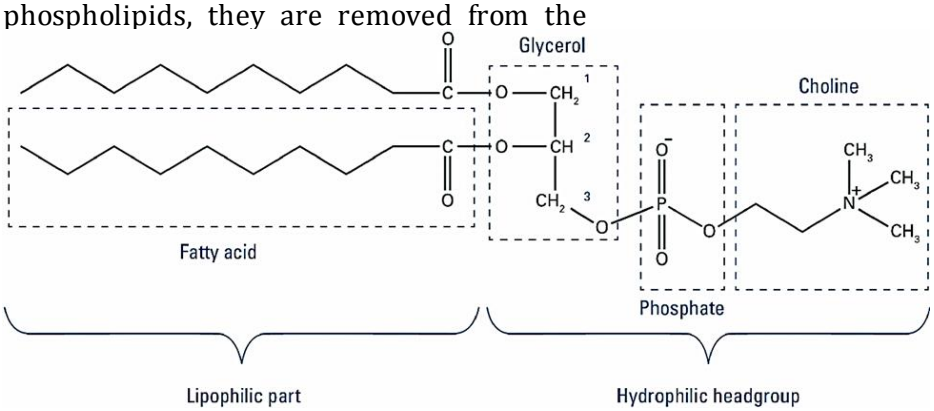

Fig. 1. Structure of the phosphatidylcholine molecule

Thus, the so-called "associates" are created between water and phospholipids [5], which, under the influence of gravity, settle to the bottom of the degumming reactor and are separated from the oil by separation or decantation in the form of lecithin gum.

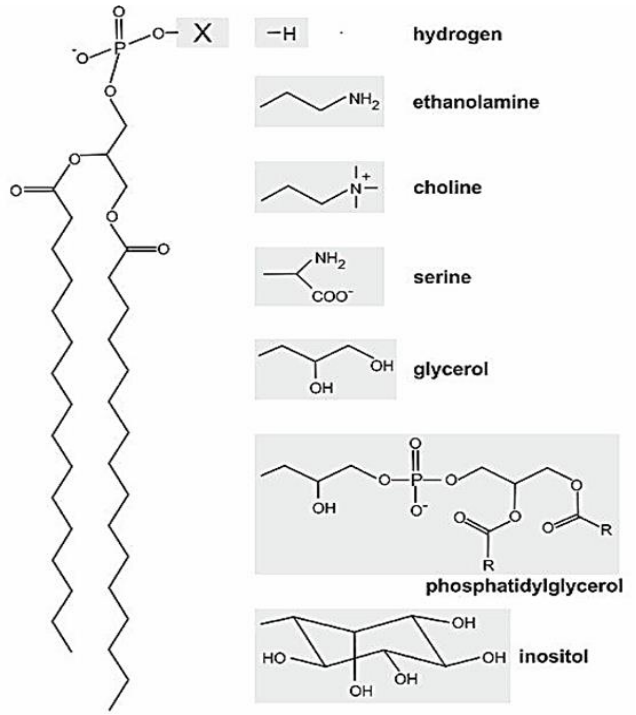

Fig. 2. Varieties of phospholipids contained in vegetable oils

However, simple water degumming cannot provide a low residual phospholipid content in refined oil due to the fact that not all phospholipid groups are removed during water degumming. The varieties of phospholipids contained in the vegetable oils are shown in Fig. 2. Phosphatidylinositol is easily hydrated with water due to the presence of five free hydroxyl groups on the inositol fragment. The hydrophilicity (that is, in this case, the ability to be removed from the oil by water) of other phospholipid groups depends on their ability to form an internal salt at certain pH values (between a negatively charged phosphorus and a positively charged amine group – Fig. 1, 2). The most important fraction of phospholipids, phosphatidylcholine, does not form an internal salt at any pH value (positive and negative charges in the phosphatidylcholine molecule are far from each other and do not contact) and therefore is hydrophilic at any pH value [6]. That is, after a long-lasting water degumming, the final amount of phosphatidylcholine and phosphatidylinositol in the degumming oil is visible [7]. To remove phosphatidylethanolamine, acidic environment is required. As the pH rises, phosphatidylethanolamine is beginning to form an internal salt and is losing its hydrophilicity. Phosphatidic acids, on the other hand, become hydrophilic in an alkaline environment (the molecule becomes positively charged). Therefore, these phospholipid groups should be considered only partially hydrophilic (they are part of phospholipids, are hydratable and non-hydratable [7]. The so-called non-hydratable phospholipids (mainly calcium and magnesium salts of phosphatidic acids, as well as phospholipids associated with sodium, potassium, calcium, and iron) are not hydrated at any pH. Therefore, to ensure a low content of phospholipids in refined oil, it is necessary to use a degumming agent that will interact with most of these forms of phospholipids and convert them into a hydrophilic form [8].

One of the best degumming agents are acids [9–11]. Citric, phosphoric or other acid added to the oil displaces the phosphatidic acid from its salts (mainly calcium and magnesium salts). The formed non-dissociated phosphatidic acid contains of two fatty acid residues, namely, it is still able to dissolve in the fats and is not able in the water. When the pH is raised by the addition of water, phosphatidic acid forms a sodium salt, which has a significant dipole moment and is hydrophilic, accordingly. After acid degumming, neutralization is usually carried out [12], during which practically all phosphatidic acids are removed from the oil (mainly in the form of

monosodium salt) [13]. The other most widespread degumming option today is the use of enzymes [14; 15]. The degumming stage produces a valuable by-product - phosphatide concentrate or liquid lecithin, which is widely used in the food and pharmaceutical industries due to its various technological functions (emulsifier, antioxidant, stabilizer, defoamer, etc.) [16; 17].

Modern degumming technology must solve two problems. The first one is the derivation of the maximum number of different forms of phospholipids. The second one is the possibility to obtain a by-product – lecithin with quality indicators that meet international requirements.

Different countries use different methods for studying the quality of lecithins, therefore, the requirements for them are different. Comparative analysis of the requirements for lecithins is summarized in table. 1. A significant difference is observed in the identification of such indicators as the mass fraction of mechanical impurities and color.

Table 1

Requirements for lecithins

Indicator	SOU 15.4-37-212:2004 "Phosphatide concentrates. Specifications "	GOST 32052-2013 Food additives. Lecithins E322	EU E 322 [16]
Acetone-insoluble matter, %	60	60	60
Moisture and volatile matter content, %	1.0	1.0	Loss on drying. Not more than 2 % (105 °C, 1 h)
Mass fraction of mechanical impurities	Ethyl ether insolubles. Not more than 1.5 %	Toluene-insolubles. Not more than 0.3 %	Toluene-insolubles. Not more than 0.3 % (some companies use the hexane-insolubles ≤ 0.5 % indicators)
Acid value, mg KOH/g, not more than	Acid value of oil isolated from phosphatide concentrate, mg KOH/g, 10	36	not more than 36 mg of potassium hydroxide per gram
Peroxide value, mmol ½ O/kg, not more than	Peroxide value oil isolated from phosphatide concentrate, not more than 10 mmol ½ O/ kg	10	10
Viscosity at 25 °C, Pa·s, not more than	12	12	12
Color	Color, mg of iodine, not more than – 8 (1% solution in hexane)	Color of a 10 % solution in toluene, mg of iodine < 80	Unit of Gardner color scale – 17

The two main problems of sunflower lecithins produced in Ukraine, which often do not allow to call them the international term «lecithin» – are , firstly, the possible high content of mechanical impurities (insoluble in hexane, toluene or in ethyl ether according to various standards countries), and secondly, high viscosity. The problem of high content of mechanical impurities is solved by effective filtration of oil before refining (separators are used for this purpose). Therefore, there is no need to solve the first problem in this study. The decrease in viscosity is possible during the technological exposure to the lecithin, preferably during the lecithin drying stage. Even more appropriate is the injection of phospholipid diluents at the stage of degumming of the oil.The viscosity of lecithins is a complex parameter that depends on the content of acetone-insoluble substances (actually phospholipids), moisture, mineral content, free fatty acids, fatty acid composition of acyl phospholipids, etc. Typically, higher levels of acetone-insoluble substances and water result in higher viscosity, while higher levels of free fatty acids often reduce viscosity [18]. When the content of acetone-insoluble substances in soy lecithin is about 62 %, it is possible to obtain liquid lecithin. The so-called plastic form of lecithin is obtained at acetone-insoluble substances content of 65 %, , in this case lecithin has thick, plasticine-like consistency. Lecithin also tends to "plasticize" during storage, that is to increase viscosity. It is important to note that the maximum tendency to plasticization is observed at a moisture content of about 0.7 %.The cheapest way to reduce the viscosity of a lecithin is to inject the salt solution before drying the lecithin gum. It is more expedient to enter it at a degumming stage - salt is evenly distributed in phospholipids, thus the efficiency of degumming increases. For example, [19] describes a method of degumming, in which a solution of sodium chloride with a concentration of 2–5 % (with the addition of nonionic surfactants with a concentration of 0.02–1 %) is used as a degumming agent. However, such degumming is ineffective (the final content of phospholipids in refined oil is 0.2–0.3 %). All 2–5 % of sodium

chloride get to lecithin and remain in it in the form of so-called mechanical impurities, and their content according to the requirements of European standards should not exceed hexaneinsolubles ≤ 0.5 %.A more common way to reduce the viscosity of lecithins is to add fatty acids. Fatty acids have a significantly lower density compared to lecithin, and are its natural components. However, their use in an effective amount of 2–10 % is accompanied by a significant increase in the acid value and a decrease in the content of acetone-insoluble substances in the lecithin. The same (except for increasing the acid value) applies to the use of ethyl or other esters of fatty acids [18, 20].

Divalent metal salts can also effectively reduce the viscosity of lecithin [21]. Therefore, it is necessary to select and investigate a substance that, in addition to reducing the viscosity of the lecithin, will also be a highly effective degumming agent.

Calcium acetate (the formula is $Ca(CH_3COO)_2$) is registered as a food additive E263 (preservative, acidity regulator).Its most common commercial form – monohydrate $Ca(CH_3COO)_2 \cdot H_2O$ is fully absorbed by the human body. The permissible dailyintake is not limited, which indicates the safety of this substance. Acetates are normal components of the diet of humans and animals and are produced in molar quantities in the gastrointestinal tract. They are fully metabolised and so do not pose a risk to the environment [22]. Calcium acetate is used in pharmaceuticals to prevent bone loss and improve bone microarchitecture [23]. The presence of the CH_3COO^- group in its molecule leads to the possibility of excretion of phosphatidylethanolamine and part of non-hydrated phospholipids. The presence of Ca_2^+ ion could enrich the phosphatide concentrate with this useful element for human health.

Thus, in our opinion, calcium acetate can be an effective degumming agent capable of reducing the phospholipid content in sunflower oil to low final values (less than < 0.05% in terms of stereooleolecithin). At the same time, this additive should have a positive effect on reducing the viscosity of sunflower lecithin obtained as a result of degumming. Considering the safety of calcium acetate, such a study to find its dual technological effect looks relevant. The purposes are: to study the effectiveness of calcium acetate in terms of reducing the phospholipid content in sunflower oil, to study the effect of calcium acetate on reducing the viscosity of lecithin, which is obtained as a result of degumming of sunflower oil.

Research objectives:

- to establish the effectiveness of calcium acetate in the removal process of phospholipids from sunflower oil;
- to determine the rational conditions of degumming in the presence of calcium acetate, including enough water for such degumming;
- to determine the quality indicators of sunflower oil and lecithin obtained by degumming with calcium acetate and their compliance with modern requirements;
- to investigate the effect of calcium acetate on reducing the viscosity of sunflower lecithin.

Materials and methods

Unrefined unrehydrated crude sunflower oil was chosen as the object of the study (DSTU 4492:2017).

The degumming of sunflower oil was carried out using a magnetic stirrer with a thermocouple at a temperature of 55 °C, with constant stirring (60 rpm). The volume of the sample is 500 cm^3, the temperature was controlled with an error of ± 0.1 °C. Effect of addition of water was studied at 0.5, 1, 2.5 % loading using distilled water as the additive.

To determine the quantitative content of phospholipids of substances in oils, an express analyzer of phospholipids AMDF - 1A was used. The range of measurements of phospholipids mass fraction (Ci), %, (in terms of stereooleocytin) in sunflower oil is 0.02–1.5. The limits of relative measurement error, %, in the ranges of mass fraction (0.02–3.0) % are calculated by the formula:

$[(3.4 \cdot 10^{-3} + 0.13 \cdot Ci) / Ci] \cdot 100$.

Obtaining a phosphatide concentrate was carried out as follows. After degumming, the phases of degumming oil – lecithin gum were separated using a paper filter. The drying of the lecithin gum obtained after degumming and phase separation was carried out in a laboratory rotary evaporator at a temperature of 90 (± 0.5) ºC and a residual pressure of 5 kPa to a moisture content of < 0.5 %.

The acid value of sunflower oil was determined according to DSTU 4350: 2004 Oils. Methods for determining the acid value.

The mass fraction of moisture and volatile substances was determined according to DSTU ISO 662: 2004 Animal and vegetable fats and oils. Determination of moisture content and volatile substances.

Peroxide was determined using the acetic acid-isooctane method (AOCS Cd 8b-90) in terms of milliequivalents of peroxide per kilogram of test sample. The method is commonly used in oil processing industries.

The content of non-fatty impurities in sunflower oil was determined according to DSTU ISO 663-2003 Animal and vegetable fats and oils. Determination of the content of insoluble impurities.

The quality indicators of the obtained phosphatide concentrate were studied by SOU 15.4-37-212:2004 «Phosphatide concentrates. Specifications».

All experimental data were obtained twice. The article shows the average values. The mean deviation did not exceed 0.1 for a confidence interval of 0.95.

Results and discussion

To study the effectiveness of calcium acetate, comparative degumming was performed (aqueous, aqueous in the presence of calcium acetate and using a common in the industry degumming agent – «Phospholisorb»). The results are shown in table 2.

Table 2

The results of comparative degumming

Sample	The amount of added water, %	Phosphorus-containing substances mass fraction % in terms of stearooleolecythin	Moisture and volatile matter content, %
Water degumming	1	0.210	0.28
With phospholisorb (0.02 %)	1	0.082	0.25
With calcium acetate (0.1 %)	1	0.035	0.14
With calcium acetate (0.01 %)	1	0.042	0.12

The results of study (Table 2) showed a significantly higher efficiency of using as the degumming agent the aqueous solution of calcium acetate, compared with other degumming agents. It is important to note that even if using 0.01% calcium acetate, the final content of phospholipids in rafined oils is low – 0.042 %.

Also the use of the rational amount of water as part of the degumming agent is of considerable interest. The recommendations and norms applied in manufacturing derived from scientific researches are quite different (from 1 to 2.5 % of water for sunflower oil). Despite the fact that water as the main degumming agent has reasonable price, the cost of its evaporation at the stage of drying the lecithin gum is significant.

The results of the studies of the effect of water on the efficiency of degumming (the content of phospholipids in refined oil) are shown in Fig. 3.

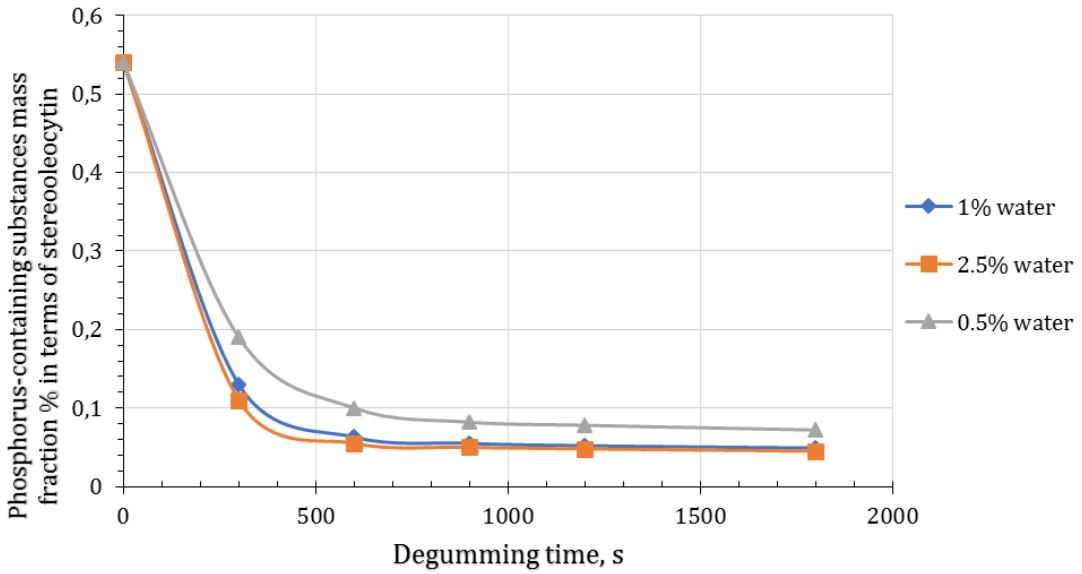

Fig. 3. Kinetics of degumming at a concentration of calcium acetate 0.005% and 0.5; 1; 2.5% of water

Graphs of degumming kinetics with 2.5 and 1 % of water are very similar, it can be concluded that increasing the water content to more than 1 % under conditions of using calcium acetate does not lead to a decrease in the final content of phospholipids in refined oil. It should be noted that this result is caused by the efficient mixing of the oil-water phases. That is, during

degumming, all phospholipids that can be removed from the oil in contact with the water-calcium acetate system, obtain this opportunity. This degree of mixing is easy to be created in the laboratory (due to the small volume of samples), however the conditions for mixing phases should be carefully selected in manufacturing..

The research results (Fig. 3) show the presence of an inflection point in the kinetic curves of phospholipid removal during degumming with a process duration of approximately 8 min. That is, this duration should be considered rational. However, considering the goal of degumming as the most complete removal of phospholipids, the duration of degumming can be increased.

Parameters such as the amount of degumming agents, the duration of the process, the temperature are interrelated, so it was decided to use experimental planning methods for further research. The planning matrix of the complete factorial experiment (CFE) of type 2k is given in table. 3.

Factors that significantly affect the effectiveness of degumming, according to experiments, are the amount of degumming agent, the amount of water and the duration of degumming. Other factors – temperature, mixing intensity were decided to remain unchanged (the wishes of sunflower oil producers).

Table 3

Planning matrix of an experiment on the degumming of sunflower oil in the presence of calcium acetate

№	X_0	Concentration of calcium acetate, %, X_1		Duration of degumming, min. X_2		The amount of water, % X_3		The content of phospholipids in refined oil, % in terms of stearooleolecythin (study repeated twice)	
1	+1	+1	0.01	+1	30	+1	2.5	0.032	0.033
2	+1	+1	0.01	+1	30	-1	1	0.039	0.039
3	+1	+1	0.01	-1	10	+1	2.5	0.042	0.042
4	+1	-1	0.005	+1	30	+1	2.5	0.050	0.049
5	+1	-1	0.005	-1	10	+1	2.5	0.060	0.059
6	+1	-1	0.005	+1	30	-1	1	0.050	0.048
7	+1	+1	0.01	-1	10	-1	1	0.041	0.042
8	+1	-1	0.005	-1	10	-1	1	0.062	0.063
9	+1	0	0.0075	0	20	0	1.75	0.056	0.056
10	+1	0	0.0075	0	20	0	1.75	0.057	0.055

As a result of processing the data of the factorial experiment according to [24], a regression equation was obtained, which describes the concentration of degumming agents and the duration of degumming process on the final content of phospholipids in the oil:

$$Y=0.0081875\cdot X_1 + 0.0044375\cdot X_2 + 0.0010625\cdot X_3 - 0.0014375\cdot X_1\cdot X_2 + 0.0004375\cdot X_1\cdot X_3 + 0.0004375\cdot X_1\cdot X_2$$

The correlation coefficient of the equation $R^2 = 0.83$.

From the obtained regression equation it could be seen that the amount of calcium acetate has the greatest effect on the low final content of phospholipids in the oil. The duration of degumming (in the range of 10–30 min) has a significantly smaller effect. The third factor of variation is the amount of water (in the range of 1–2.5 %) which practically does not change the final content of phospholipids in the oil (corresponding to Fig. 1). Regarding the mutual influence of factors: a simultaneous increase in the amount of calcium acetate and the duration of degumming shows the additivity of their total effect (it is necessary to either increase the concentration of calcium acetate, or the duration, but not simultaneously). All other paired options increase the effectiveness of degumming, but only slightly.

The following rational parameters of degumming with calcium acetate can be recommended: the amount of calcium acetate – 0.01 %; the duration of degumming – 10 minutes; the amount of water – 1 %.

To prove the possibility of using a new degumming agent, it is also necessary to determine its effect on oil quality indicators. The results are shown in table. 4.

The data in table 4 indicate the safety and efficacy of calcium acetate as a degumming agent. All quality indicators of rafined sunflower oil meet the requirements of regulatory documents. A patent has been obtained for the method of degumming using calcium acetate [25].

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Table 4

Quality indicators of sunflower oil before and after degumming

Indicator	Quality indicators of sunflower oil before degumming	Quality indicators of sunflower oil after degumming (1 % water, 10 min.)	Quality indicators of sunflower oil after degumming (1 % water, 0.01 % calcium acetate, 10 min.)
cid, mg KOH/g	1.4	1.3	1.5
peroxide, mmol½O/kg	3.5	3.6	3.2
Mass fraction of phosphorus-containing substances % in terms of stearooleolecythin	0.54	0.21	0.04
Moisture and volatile matter content, %	0.15	0.28	0.12
Content of non-fatty impurities, %	0.02	–	–
Color, mg of iodine	16	15	14
Taste and odor	Inherent sunflower oil without foreign odor, taste and bitterness		

It is also necessary to investigate how the presence of calcium acetate affects the quality of lecithin. The results of studies of sunflower lecithin obtained after drying the lecithin gum are summarized in table. 5.

Table 5

Quality indicators of lecithin obtained by degumming in the presence of calcium acetate (calcium acetate concentration is 0.01 %)

Indicator	The obtained sunflower lecithin	Requirements of SOU 15.4-37-212:2004 "Phosphatide concentrates. Specifications "
Acetone-insoluble matter, %	61.2	≥ 60
Moisture and volatile matter content, %	0.13	< 1.0
acid in the oil isolated from phosphatide concentrate, mg KOH/g	2.3	<35
peroxide in the oil isolated from phosphatide concentrate, mmol½ O/kg	3.5	≤ 10
Ethyl ether-insoluble matter, %	0.6	≤1.5
Viscosity at 25 °C, Pa·s	9	≤ 12
Color, mg of iodine	6	≤ 8

All quality indicators meet the requirements of regulatory documents. However, the amount of calcium acetate used for degumming and, accordingly, consists in lecithin is not high (0.01 %), it is not enough to effectively reduce the viscosity of lecithin. Therefore, it is necessary to investigate the change in the viscosity of lecithin under the influence of higher concentrations of calcium acetate.

Degumming of sunflower oil with 0.1–1.5 % of calcium acetate (relative to the oil) was performed. The separated lecithin gum was dried to a moisture content of < 1 %. The results of the change in the viscosity of the obtained lecithin depending on the content of calcium acetate are shown in Fig. 4. Since lecithin can increase viscosity (be plasticized) during storage, the viscosity was determined 14 days after drying.

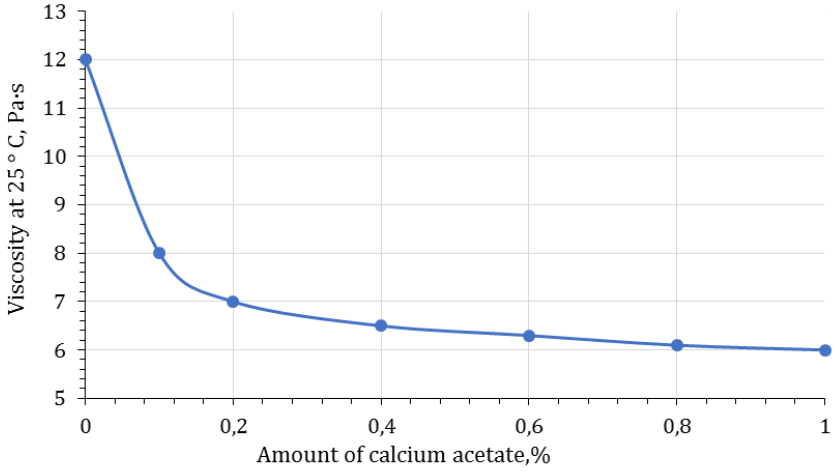

Fig. 4. Impact of calcium acetate on the dynamic viscosity of sunflower lecithin

As can be seen in the Fig. 4, the concentration of 0.2 % calcium acetate is sufficient to significantly reduce the viscosity to the values at which lecithin does not form a plastic consistency. A further decrease in viscosity with increasing the content of calcium acetate also occurs and becomes slower when the content of Ca $(CH_3COO)_2$ in lecithin is greater than 1 %.

Conclusion

A new degumming agent, calcium acetate, has been proposed and investigated. It is proved that even at low concentrations (≤0.01 %) it is possible to obtain refined sunflower oil with a phospholipid content of ≤ 0.05 %. A 93% reduction in phospholipid content indicates the effectiveness of the proposed degumming agent.

The rational parameters of degumming in the presence of calcium acetate have been established: the amount of calcium acetate is 0.01%; the duration of degumming is 10 minutes; the amount of water is 1%. Limiting the water content to 1% has a significant result in the increasing of economic efficiency of the lecithin stage (all water added during the degumming stage remains in the lecithin gum; water must be evaporated to obtain the lecithin; reducing the water content will save energy).

The qualitative indicators of oil and lecithin obtained as a result of degumming with calcium acetate were studied. All of them meet current requirements.

It has been proven that calcium acetate added during the degumming step is also an effective agent for reducing the viscosity of lecithin. Sunflower lecithin is not being plasticized during storage, even if the amount of calcium acetate is 0.1 %. With 0.2 % of calcium acetate introduced in the degumming step, lecithin is obtained with the viscosity of 8 Pa·s (at 25 °C).

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