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SELECTION OF AN EFFECTIVE ALKALINE REAGENT FOR THE NEUTRALIZATION OF SAFFLOWER OIL

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Abstract

This paper presents the results of a study of the purification process during the refining of bile oils in the presence of an aqueous solution of sodium silicate. It has been established that in this case the yield of neutralized horseradish oil increases in relation to caustic soda. The achieved values of quality indicators of neutralized bile oil are much higher.

Keywords: safflower, seeds, oils, refining, aqueous solution, sodium silicate, soap stock.

Introduction

In nature, vegetable oils, in particular safflower oils, contain, in addition to triglycerides, many related substances, some of which are harmful to a healthy diet. Therefore, their composition and the content of substances accompanying triglycerides are initially studied, according to which the processes of their complex refining are organized [1-11].

The theoretical foundations of the complex refining of vegetable oils are described in detail in the monograph. Complex refining of vegetables, in particular safflower oils, is carried out in the following sequences of processes: hydration, neutralization and bleaching. However, in practice, it is not always expedient to carry out all of the above processes. this reduces the yield of refined oil obtained, increases the consumption of materials, energy and others [4-16].

Hydration is carried out in order to extract phospholipids from vegetable oils. They are biologically active substances and natural non-ionic surfactants [2].

Phospholipids occupy the second place in the composition of vegetable oils, after triglycerides, and their isolation as separate products is dictated by the need to increase the yield of neutralized oil and satisfy surfactant consumers in the confectionery, baking, pharmaceutical and other industries [6-17].

According to the content of phospholipids, safflower oil occupies one of the leading places among vegetable oils, their content ranges from 0.3 to 0.9%. The

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group composition of safflower oil phospholipids is mainly represented by phosphatidylcholines (48.4-50.4%), phosphatidyl-inositols (20.4-22.6%) and phosphatidylethanolamines (14.1-14.3%). In addition, there is information about the presence of such forms of phospholipids as polyglycerophosphatides and phosphatidic acids [12-24].

Materials and methods

The fatty acid composition of phospholipids is qualitatively identical to the lipid composition of the safflower seed kernel. According to the degree of saturation increase for the main groups of phospholipids, regardless of the seed variety, a certain sequence is characteristic: phosphatidylcholines, phosphatidylethanolamines, phosphatidylinositols [3-18].

Phospholipids of safflower seed oils contain a small amount of cyclopropenoid acids, mainly malvic acid (1.8% of the total fatty acid content in the phosphatidylcholine fraction), which is localized in the sn-2-position of the phosphatidylcholine molecule [7-15].

It is known that phospholipids are chemically active compounds. During maturation, storage and, especially, under the influence of heat, moisture, pressure, friction and atmospheric oxygen during the processing of safflower seeds, they are able not only to oxidize and hydrolyze but also interact with sugars to form melanoidin compounds, which turn into oil [9-14].

The extraction safflower oil contains about 0.5% (in terms of stearoleolecetin) of phosphatides, which are divided into hydrated and non-hydrated. Phospholipids in safflower seeds are localized mainly in the non-fatty phase in the free and associated with proteins and carbohydrates state: depending on the methods and modes of obtaining unrefined safflower oils, the degree of simultaneous extraction of phosphatides from seeds reaches 90% [8-19].

The composition of safflower phospholipids includes glycerol- and inositophosphotides, sphingomyelins.

The most important indicator of phosphatides is their ability to show surface activity at various phase boundaries. The phosphatidic acids contained in them, phosphatidylserine and phosphatidylinositol, are ways to interact with alkali, alkaline earth and other metals due to their acidic properties.

Phosphatides are not stable in oil and even during short-term storage, they are partially released, forming a precipitate.

When bleaching safflower oil, phosphatides are partially sorbed by adsorbents, which leads to an increase in the consumption of the latter.

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In practice, existing hydration methods and their technological options do not provide complete extraction of phosphatides from safflower oil. Remaining in hydrated and even refined safflower oils, they reduce their quality and technological properties.

Non-hydratable phosphatides include phosphatidic and polyphosphatidic acids, phosphatidylserine, other acidic forms of phosphatides and their salts with metals (Ca2+, Mg2+, Na+, etc.), as well as compounds of phosphatidic and polyphosphatidic acids with sterols and aliphatic alcohols. An analysis of the dipole characteristics of individual groups of non-hydratable phosphatides showed that the polarity is lower than that of hydrated phospholipids. Non-hydratable phosphatides are found in oil (non-polar solvent) in the form of individual truly dissolved molecules (compounds of phosphatidic acids with sterols and aliphatic alcohols), or in the form of low-order associates (micelles), dimers with a total dipole moment equal to or close to zero. In these conditions, they have high aggregative stability in solutions [21-23].

The optimal temperature for the hydration process of safflower oil is 40-50+9. If we take into account that this process proceeds with the release of heat, then with a decrease in temperature, a greater depth of hydration can be expected. This increases the viscosity of the oil, which makes subsequent phase separation more difficult.

In practice, demineralized water (condensate) is more often used as a hydrating agent. At the same time, to increase the yield of released phosphatides, food-grade surfactants, organic and inorganic acids, alkalis, etc. are added. The intensity of the hydration process depends on the contact of the phases and, therefore, methods of influence are more often used. In the literature, there are works on the use of electromagnetic forces to destroy existing associates (micelles) in vegetable oils [10].

Therefore, the intensification of the process of hydration of safflower oil to increase the yield of phospholipids is considered a practically important task. In this aspect, of great interest is the method of mechano-chemical activation (MCA) of safflower oil, which does not require significant material costs [13].

In the technological chain of safflower oil processing, it must first be hydrated and further, its alkaline refining, which makes it possible to obtain individual products for various purposes. The purpose of the safflower oil hydration process is to release phospholipids with the help of water [5].

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Their neutralization with an alkaline reagent is a mandatory process for processing safflower oils, where the maximum value of the acid numbers of the latter does not exceed 0.3 mg KOH/g

In contrast to the traditional alkaline refining of cottonseed oils using an aggressive aqueous solution of NaOH, the process of neutralizing safflower oils can be carried out with a less active aqueous solution of sodium silicate with an excess of 20-50% by weight of the oil. At the same time, the saponification of neutral triglycerides is significantly reduced and, as a result, the yield of neutralized safflower oil is increased [22].

Now at the oil and fat enterprises of Uzbekistan, due to the lack of experience in the use of sodium silicate, the neutralization of safflower oils is carried out with caustic soda (NaOH), which increases the waste of valuable oil in the soapstock [20].

To select the optimal technological regimes for the neutralization of safflower oils using sodium silicate, we conducted a series of experiments in a laboratory setup. The concentration of an aqueous solution of sodium silicate was 120 g/l and its excess was 30%.

Experimental Part

Table. 1 shows the results of alkaline neutralization of safflower oil using sodium silicate and caustic soda (control).

Table 1. Comparative indicators of the process of neutralization of safflower oil using sodium silicate and caustic soda (control)

The name of indicators	Source safflower oil	Oil, neutralized	
		an aqueous solution of sodium silicate	aqueous solution of caustic soda (control)
Acid number, mg КОН/г	1,65	0,15	0,28
Mass fraction	0,34	0,03	0,09
Phospholipids, %	60	20	30
Color, mg J_2	12,05	3,55	4,65
Peroxide number, 1/2 0mmol/kg Exit, %	-	98,22	95,73

From Table. 1 it can be seen that, compared with the known aqueous solution of caustic soda (control), the use of an aqueous solution of sodium silicate makes it

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possible to reduce the acid number of safflower oil from 1.65 mg KOH/mg to 0.15 mg KOH/g to, the mass fraction of phospholipids from 0, 34% to 0.03%, colour - from 60 mg J_2, peroxide number - from 12.05 1/2 0 mmol/kg to 3.55 1/2 0 mmol/kg. The achieved values of quality indicators of neutralized safflower oil are quite high

At the same time, the yield of neutralized safflower oil when using an aqueous solution of sodium silicate in comparison with the known caustic soda (control) increases from 95.73% to 98.22% i.e. by 2.49%. This is achieved by improving the selectivity of the safflower oil neutralization process using an aqueous solution of sodium silicate.

It is known that sodium silicate, unlike caustic soda, forms a siliceous gel in an aqueous solution, which, together with sodium salts of fatty acids and substances associated with triglycerides, passes into soap stock, changing its traditional composition, rheological properties, etc.

Taking this into account, we analyzed the compositions of soap stocks obtained by the known (control) and the proposed method (Table 2).

Table 2. Comparative indicators of safflower soap stocks obtained using known caustic soda (control) and the proposed sodium silicate

Name of soapstock indicators	**safflower soap stock obtained by**	
	proposed method	**known method (control)**
Mass fraction of total fat, % including:	49,56	56,84
- neutral fat (NJ)	22,86	28,48
- fatty acids(JK)	26,70	28,36
- ratio NJ:JK	0,86	1,01

Table 2 shows that the content of total fat in the soapstock obtained using an aqueous solution of sodium silicate is less than in the case of using the known caustic soda. The advantage of using sodium silicate is that in the soapstock the content of neutral fat in the soapstock obtained using an aqueous solution of sodium silicate is lower than in the case of using the known caustic soda. The advantage of using sodium silicate is that the content of neutral fat (NF) in the soap stock is lower (22.86%) compared to the soap stock obtained using caustic soda (28.48%). A similar picture is observed when comparing the content of fatty

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acids (FA), where the proposed method is less (26.7%) fatty acids in the soap stock than in the known (28.36%).

Such a result of analyzes of the soap stock obtained using an aqueous solution of sodium silicate can be explained as follows: sodium silicate having the composition n Na_2O m SiO_2 interacts with free fatty acids according to the following chemical reaction:

$RCOO^- + Na^+ \rightarrow RCOONa$

In this case, free silicic acids are isolated as a by-product, which, due to the content of reactive poly groups (SiOH), enter into polycondensation with the formation of polysilicic acids of various structures in the form of a colloidal solution (gels). The use of sodium silicate as a neutralizing agent makes it possible to reduce the intensity of safflower oil emulsification and avoid the formation of stable emulsions compared to the use of NaOH. The effective decolourization of safflower oil (Table 2) using sodium silicate can be justified by the adsorption of colourants on semisilicic acid silicate gel. The formation of larger soapstock flakes when using sodium silicate makes it possible to intensify the process of separation of soapstock from neutralized safflower oil.

Thus, the conducted studies allow us to draw the following conclusions:

– Replacing traditional caustic soda in the process of neutralizing safflower oil with sodium silicate allows it to be carried out more selectively:

– The saponification of triglycerides of safflower oil is significantly reduced and the yield of the latter increases; the physicochemical parameters of the resulting neutralized safflower oil is significantly increased, which fully meet the requirements of the relevant standards;

– The process of separation of soapstock from neutralized safflower oil is intensified due to a significant enlargement of the first flakes;

– The content of neutral fat in safflower soap stock is significantly reduced due to a decrease in the emulsifying ability of phospholipids;

– The ratio of neutral fat to fatty acids contained in safflower soapstock is reduced.

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Conclusion

Based on the research work carried out to develop criteria for the practical application and effective use of soap stock obtained during the refining of safflower oil, we made the following conclusions:

1. A special laboratory unit was installed for alkaline refining of safflower oil and obtaining soap stock.
2. Methods for determining the quality indicators of soap stocks obtained by alkaline refining of safflower oil have been selected.
3. An assessment of the error in measurements and analysis of the quality indicators of soap stocks obtained during alkaline refining of safflower oil was carried out.
4. The physical and chemical parameters of safflower oils obtained from seeds cultivated on rainfed and cultivated lands of Uzbekistan have been established.
5. The stereospecific composition of triglycerides and fatty acids of safflower oil cultivated on rain-fed and irrigated lands has been established.
6. It was found that in order to increase the yield of neutralized safflower oil and reduce the total fat in the obtained soap stocks, it is advisable to use an aqueous solution of sodium silicate instead of the traditional alkaline reagent NaOH.
7. It was found that the soap stock obtained by neutralizing safflower oil with an aqueous solution of sodium silicate has a thicker consistency than the soap stock obtained by using a traditional solution of caustic soda.
8. It has been established that safflower soap stock is lighter in colour than soap stock obtained after refining cottonseed oil and therefore does not require the distillation process of fatty acids obtained from it.
9. It was revealed that safflower soap stock contains more unsaturated (oleic, linoleic and linolenic) acids than soap stock obtained after refining dark cottonseed oil, which contains up to 33% of saturated (palmitic and stearic) acids.
10. It has been established that the composition of safflower soap stock neutralized with an aqueous solution of sodium silicate contains silicon, which plays the role of an adsorbent and a thickener.
11. It has been shown that fatty acids obtained after the decomposition of safflower soapstock can be used in the production of liquid soaps, special detergents, etc.
12. Based on the results obtained, we recommend that oil and fat enterprises neutralize safflower oil with an aqueous solution of sodium silicate instead of the traditional NaOH reagent under the technological regimes recommended in this work.
13. Schematically shows the various industries using safflower soap stock, which can be expanded taking into account its rheological, physicochemical and other properties.

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