Section 2. Food processing industry

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RESEARCH THEORY OF PERIODIC AND CONTINUOUS REFINING PROCESSES

Abstract. The disadvantage of the periodic method, used in the oil industry today, is that a long impregnation time is required, the alkali softens the neutral oil, and the amount of neutral oil in the soapstock increases. To overcome these disadvantages, continuous refining is recommended in this research work. In the continuous refining process, neutralization is carried out in special blenders, and the soapstocks are separated in centrifuges. This method reduces the consumption of neutral oil due to the short residence time in the process and the mutual contact of oil and alkali.

Keywords: periodic method, continuous method, alkali, centrifuge, soapstock, adsorbent, fatty acid.

The aim of processing fats for food use is to maximise the preservation of the nutritional and physiological value of the oil, without changing the glyceride part of the oil. The conditions of the individual stages of the multi-stage processing process are such that the glyceride part of the oil must not be exposed to strong effects of oxygen, heat and other technological factors. It is characterised by the presence of substances that influence the non-glycerine part of the oil, especially the appearance of the product and the subsequent refining stages [1].

Most of these substances are natural companions of oil triglycerides, while others, on the contrary, are added to the oil during production and at specific processing steps. Natural companions include phosphatides, fatty acids, pigments, various volatiles, and other substances produced during the biosynthetic processes that occur during the growth and ripening of oil crops. Such substances can be used in industry, so they must be extracted from the oil in its natural state while retaining their useful biological or technological properties in the refining process [2].

It should be noted that these substances, namely triglycerides, can undergo significant changes during seed and black oil refining, which can significantly affect the efficiency of the refining methods used. In oil refining, among the substances added to the oil may be moisture, soap residues, requiring auxiliary operations (washing, drying, etc.) [3].

The processing of fats takes place in several stages, as we mentioned above. The processes in these stages are carried out in two different ways: the periodic method and the continuous method.

When using these two methods in the oil industry, we can see that they have their own pros and cons. Let's look at each step in order so that we can understand the difference between the two methods.

Neutralisation process. Periodic neutralisation of oils consists of the following consecutive (in time) processes: formation of soap structures, their formation by coagulation and deposition.

The interaction of free fatty acids with alkali is instantaneous. The time of exposure of the alkali to the oil causes soapy structures to form [4].

The higher the concentration of the aqueous alkaline solution, the greater their ability to saponify free fatty acids. As the concentration of the alkaline solution increases, the diffusion potential of the alkali into the soap structures increases.

The separation (sedimentation) of soapstock and oil in the sedimentation process, which is a long process, practically follows Stokes' law for polydisperse systems. Soapstone settling proceeds under complex conditions of soap briquetting, decomposition and parallel chemical-colloid processes.

The transition to continuous neutralisation leads to a major change in the structure of the soaps, which is primarily due to the speed (time) of the individual stages of the process.

In the continuous neutralization process, as in the periodic process, the formation of a pellicle on the alkali droplet takes place. However, while in the periodic method pellicle formation takes a long time, in the continuous method this process lasts for a short time, i.e. from the time the alkali is added to the oil to the time of splitting in the separator.

The short contact time between the alkali and the oil is sufficient to neutralize the free fat acids, but not sufficient to saponify the neutral oil. Therefore, the neutral oil is saponified to a lesser extent during continuous neutralization.

Neutralization of black cottonseed oil is carried out under more difficult conditions than other oils. For example, the emulsion neutralization of cotton oil using the All-Russia Research and Development Institute of Fats (ARDIF) method has to deal with two soap antagonists, hydrophilic emulsifiers and gossypol, which have a negative effect on emulsification [5].

The pellicle formed on the surface of the alkali droplets at the start of the neutralization process partially adsorbs gossypol and gossypol derivatives (which have not completely lost their polar properties). The result is a homogeneous system in which the soap is distributed between the oil and the alkaline solution.

When water is added, the volume of the aqueous phase increases, which in turn causes a phase change and a break in the oil-saponification bond, i.e. separation of the system.

In the continuous neutralization of black cotton oil, the effect of gossypol and its derivatives on the stability of the system or the duration of the presence of pellicles on the oil surface must be considered. This process tells us that the behavior of toluene droplets and the concentration (composition) of the soap in the aqueous alkaline solution depend on the residence time of the droplet on the oil surface, as shown by Rebinder and Wenström [1].

Table 1.

Concentration of soap in millimoles per 1 l	Duration of "life" of the droplet on the surface (in seconds)	
	Concentration of soap	Toluene
0	0	0
0.025	0	2
0.05	0	47
0.1	1.5	28
0.5	2.0	95
2.5	5.0	223
5.0	7.0	480
10.0	12.0	1200–1800

The data in Table 1 show that the stability of the pellicles increases with increasing soap concentration. In the presence of products of phenolic nature in the oils, it increases even more.

The continuous neutralization process consists of the following successive high-speed processes: heating, dosing, mixing of oil and alkali, and separation of the soapstock.

Cleaning (washing) soap residue. The continuous separation of soap residue from the neutralised oil depends on the speed and complete dissolution in water or water-salt solution.

The amount of water required is determined by the soap content of the oil and the nature of the accompanying substances in the oil.

Thus, the accumulation of fat acids, iron and nickel salts should therefore first be removed by exposure to weak saline solutions or by treatment with a water condensate solution.

Normally, the amount of water required in the continuous oil washing process is 10–15% of the weight of the oil. This creates conditions for the molecular solubility of soap in water [2].

In a periodic process, the duration of the oil wash is determined by the time taken to mix the soap phase, dissolve by diffusion and separate the sludge. In a continuous process, time is spent only on soap melting and the separation of the sludge in a continuous mode.

Temperature is an important factor not only for separation systems, but also for ensuring that the soap dissolves completely in the water or water-salt solution. The higher the water and oil temperature, the more completely the soap dissolves in the water. As far as a continuous process is concerned, the optimum temperature is in the 90–950 °C range. A drop in the temperature of the oil or water drastically degrades the washing quality and requires repeated washes, sometimes resulting in the formation of emulsions [4].

The washing process in the continuous method is carried out in the following sequence: heating to optimum temperature, dosing, mixing and separating oil and water.

Removal of moisture from the oil composition (drying). No matter how long the sedimentation process lasts, no matter how many attempts are made to separate it in plate or tube centrifuges, it is not possible to completely eliminate the moisture in the water used to wash the soap residue. In the absence of any humectants or stabilisers, some amount of moisture (0.2–1% of the total oil mass) is always retained in a finely dispersed state [5].

The most common method of removing this moisture is vacuum drying. Continuous vacuum drying is based on the evaporation of moisture from the surface of a single drop of oil entering the vacuum dryer.

For efficient fat drying, the batch machine uses intensive mechanical agitators to help push the moist oil droplets upwards. In continuous drying, the same effect is achieved by continuously heating the oil in a vacuum. Oil heated to 35–950 °C is sent to a vacuum chamber, where the moisture is immediately separated from the oil, and the separated moisture is discharged into a condenser. The dried fat droplets collect at the bottom of the vacuum dryer column and are continuously removed [2].

Cleaning of dyes (bleaching). The change from periodic to continuous oil bleaching does not involve a change in the adsorption mechanism. The greatest difficulty arises from the need for continuous separation of the adsorbent from the oil.

With continuous bleaching, the mixing time of the oil and adsorbent is maintained. This process can be carried out in contact mixing machines, where a measured amount of oil and adsorbent is premixed and sent to the machine. The mixing time is determined by the nature of the adsorbent and the colouring pigments of the oil and can range from 15 to 45 minutes [6].

A continuous scheme for bleaching oil with solid adsorbents includes the following sequential processes: heating oil, weighing oil and adsorbent, mixing oil and adsorbent, separating adsorbent.

Cleansing of taste and odour imparting substances (deodorisation). Despite the obvious advantages of this method, continuous deodorisation of oil is still not used in some plants.

The most important advantage of continuous deodorisation, which distinguishes it from intermittent deodorisation, is a constant vacuum and temperature.

The continuous deodorisation process creates a constantly reproducible environment for each particle of deodorisable oil, where each drop of oil is always exposed to the same high vacuum and temperature.

Schematically, deodorisation consists of the following processes: continuous heating of de-aerated oil, deodorisation in small layers, continuous heating with dry steam, separation of flavouring and odorous substances and partial free fatty acids, and cooling to a certain temperature.

Conclusion. The periodic neutralization method is currently used to treat moderate amounts of oil. This method is carried out in neutralizers with capacities of 5, 10, and 20 tons. The disadvantage of the periodic method is that this process requires a long soaking time, as this process lasts a long time, the lye softens the neutral oil, which increases the amount of neutral oil in the soapstock as a result. Soapstock has a fat content of 30–50%.

In the continuous neutralisation method, the most efficient method is to separate the neutral oil soapstick phases in the field of centrifugal force. In this case the neutralisation is carried out in special mixers and the separation of the soapstocks is carried out in centrifuges. The advantage of this method is the short time needed for the process and the fact that oil and alkali are in short contact with each other, the oil consumption is neutral and the oil content of the soapstock is at a standard level.

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