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RESEARCH OF HYDROGENIZATION OF SOYBEAN OIL

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Abstract

In our research, we studied scientific and practical studies of stable and dispersed catalysts that improve the oxidation resistance and quality of unconventional oils, expand the scope of salomas, and improve the technology of oil hydrogenation. In the course of the study, complete saturation with linolenic acid was achieved by partial hydrogenation of soybean oil in the presence of a nickel-copper catalyst. It was found that the iodine content is about 100% J_2, the melting point is 18-230 °C, and the linoleic acid content does not exceed 25%, an oil with high oxidation resistance can be obtained.

Keywords: Soybean oil, linoleic acid, hydrogenation, glyceride, antioxidants, fatty acids.

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Introduction

Soybean oil is an important source of highly unsaturated essential fatty acids such as linoleic and linolenic, which are easily and quickly absorbed. In addition, the lipid fraction of soy contains biologically valuable components: tocopherols, phytosterols, phospholipids and other substances. Most of these valuable substances are lost during the extraction of soybean oil. Therefore, the development of a technology that maximizes the beneficial components of lipids in fatty materials and increases resistance to fat oxidation is one of the urgent problems [1-3].

Soybean oil is also rich in nutrients due to its high content of proteins, phosphatides and natural vitamins. In addition, the production of soybean oil is increasing day by day due to the relatively low cost of growing and producing it.

It is known that soybean oil contains 50-57% linoleic and 7-9% linolenic acids. These acids have a high level of unsaturation, which allows the soybean oil to be digested quickly. At the same time, these acids have a high tendency to oxidize, and their oxidation leads to the appearance of unpleasant odors and tastes in soybean oil. This, in turn, limits the consumption and shelf life of soybean oil [2-6].

To overcome these disadvantages of soybean oil, it is recommended to first reduce the amount of linoleic acid by eliminating linolenic acid from it. This will increase its oxidation resistance and improve its quality [10].

Numerous studies of the loss of the specific smell and taste of soybean oil, increasing its resistance to oxidation and improving its quality have led scientists to the following conclusion. Create genetically modified soybeans that do not contain or have reduced levels of highly unsaturated fatty acids such as linolenic and linoleic acids [11].

Experimental Part

Add antioxidants to the oil to reduce oxidation of unsaturated compounds. Однако у этого метода есть ряд недостатков. In particular, all antioxidants are expensive and not resistant to high temperatures. In addition, fewer antioxidant oils are required by food manufacturers. Mixing liquid oils with a high content of unsaturated fatty acids (soy, rapeseed,

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sunflower) with fats and oils rich in saturated fatty acids (cotton, safflower, animal fats). This method also has several advantages and disadvantages. When fats are mixed together, the amount of unsaturated acids, which are very prone to oxidation, is significantly retained, which leads to a deterioration in the quality of the oil [4-8]. The most commonly used catalytic hydrogenation is the hydrogenation and reduction process of triglyceride compounds. Today, reducing linolenic and linoleic acids during the catalytic hydrogenation of soybean oil and increasing its oxidation stability remains a practical and promising method. This will not only improve the quality of the oil, but it will also produce a wide variety of oils and fats that can be used for a variety of purposes. In addition, the shelf life of the soybean oil is extended. The literature states that the selectivity of hydrogenation of a mixture of glycerides of linolenic, linoleic and oleic acids depends on the nature and structure of the catalyst, process temperature, hydrogen pressure, amount and activity of the catalyst, and hydrodynamic conditions [3-9].

Copper catalysts have the highest selectivity among industrial catalysts. They practically do not hydrogenate derivatives of monoatomic acid under hydrogen pressure up to 0.15 MPa. The hydrogenation of linoleic acid derivatives in a copper catalyst is absolutely selective. When hydrogenating linolenic acid derivatives in a copper catalyst, the selectivity does not exceed Sle = kle / kl 12 and is saturated to linoleic acid. The selectivity for the hydrogenation of linolenic acid glycerides in nickel and other catalysts is much lower, while the selectivity for the hydrogenation of linoleic acid varies.

Table 1. Changes in the hydrogenation of soybean oil during hydrogenation

Hydrogenate sample	Hydrogenation time, min.	Hydrogenate indicators Ni: Cu Iodine number, % J_2	$T_{me.}$ ^oC	Acid number, mg KOH	N-210 Iodine number, J_2 2%	$T_{me.}$ ^oC	Acid number, mg KOH
	0	137,1	<15	0,20	137,1	<15	0,20
1	10	123,6	<15	0,20	129,1	<15	0,20
2	20	114,5	<15	0,21	122,2	<15	0,21
3	30	108,4	<15	0,23	113,3	15,3	0,24
4	40	104,7	18,8	0,25	103,4	18,2	0,27
5	50	98,6	21,6	0,28	94,5	22,7	0,31
6	60	93,8	24,3	0,32	87,3	26,5	0,34

Based on the above data, experiments were carried out on the partial hydrogenation of sample 1 of soybean oil in order to increase its resistance to oxidation [5]. The experiments were carried out in a laboratory setup using a Ni: Cu mixture and a new catalyst in a ratio of 80:20 and catalyst N-210, T = 200 °C, provided that the catalyst content was 0.2% by weight of oil. The hydrogenation time was 60 minutes, samples were taken every 10 minutes and their iodine content was analyzed. The results of the experiment are presented in table 1.

The experimental results (table 1) show that with an increase in the hydrogenation time, the amount of iodine in the obtained hydrogenate decreases, and the melting point and acid number increase [12].

Iodine is about 100% J_2, has a melting point of 18–230 °C and a linoleic acid content of no more than 25%. If we look at the results of the above experiment, we can see that the hydrogenate is close to 100% J_2 and the melting point is in the range 18-230 °C in Samples 4-5 of the experiment with Ni: Cu catalyst. That is, when the hydrogenation temperature is 200 °C, the hydrogenation time is 40-50 minutes, the iodine number of the obtained hydrogenate is 104.7-98.6% J_2, the melting point is 18.8-21.6 °C, and acid number 0.25-0.28 mg was equivalent to KOH. We see that a hydrogenated product with a similar index can be obtained in the presence of catalyst N-210. The iodine content in the resulting hydrogenate was 103.4-94.5% J2, and the melting point was 18.2-22.7 °C.

It is very important how the content of fatty acids in the oil changes during hydrogenation. This is due to the fact that, in addition to the resistance of the oil to oxidation, its digestibility is also directly related to the content of fatty acids in it. Therefore, the content of fatty acids in hydrogenates obtained by partial hydrogenation of soybean oil was determined. The analysis results are presented in tables 2 and 3.

Table 2 Change in the content of fatty acids during the hydrogenation of soybean oil in the presence of a Ni: Cu catalyst

Sample	The amount of fatty acids,%				
	$C_{16:0}$	$C_{18:0}$	$C_{18:1}$	$C_{18:2}$	$C_{18:3}$
1	10,1	4,2	22,8	54,1	8,8
2	10,1	4,2	32,4	47,9	5,4
3	10,1	4,2	41,8	40,2	3,7
4	10,1	4,2	48,7	34,6	2,4
5	10,1	4,3	54,9	29,1	1,6
6	10,1	4,8	60,0	25,3	0,8
7	10,1	5,2	63,8	20,8	0,06

As can be seen from Table 3, the change in the amount of fatty acids over time shows that linolenic acid decreased from 8.8% to 0.06%, while stearic acid appeared to increase from 4.2% to 5.2%. Since hydrogenation with the expected parameters is achieved within 40-50 minutes of hydrogenation, the content of stearic and linolenic acids in this range is 4.3-4.8 and 1.6-0.8%, respectively.

Table 3. Change in the content of fatty acids during the hydrogenation of soybean oil in the presence of catalyst N-210

Sample	The amount of fatty acids,%				
	$C_{16:0}$	$C_{18:0}$	$C_{18:1}$	$C_{18:2}$	$C_{18:3}$
	10,1	4,2	22,8	54,1	8,8
1	10,1	4,2	28,8	50,4	6,5
2	10,1	4,3	35,6	45,7	4,3
3	10,1	4,5	44,7	37,5	3,2
4	10,1	5,6	52,0	30,2	2,1
5	10,1	6,4	58,2	24,0	1,1
6	10,1	7,7	64,1	17,6	0,5

Analyzing the data in both tables above, when soybean oil is hydrogenated in the presence of Ni: Cu and N-210 catalysts to obtain hydrogenates with almost the same iodine number, the amount of linolenic acid in the hydrogenate obtained in the presence of N-210 is Ni: Cu. We see that this is

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more than the hydrogenation obtained in the presence. This is due to the high linolenic selectivity of the copper catalyst, as noted above.

Conclusion

Hydrogenation of soybean oil is a more complex process, in the presence of a highly active catalyst, a violation of the relationship between the melting point of the hydrogenate and the amount of iodine, ie the "delay" of the melting temperature. In other words, when a product with the required amount of iodine is obtained, its melting point and hardness will be much lower than expected. Such a deficiency is eliminated if the mixture of soybean oil with cottonseed oil is hydrogenated.

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