THE OPERATOR MODEL OF HIGH GOSSYPOL COTTON OIL EXTRACTION, FUNCTIONAL SCHEME OF TECHNICAL GOSSYPOL EXTRACTION AND OIL REFINING

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ABSTRACT
This article presents a functional scheme for the production of high-density cottonseed oil using ultra-high-frequency beam processing of cottonseed meal, indicators of stability and integrity of production models of the operator model. The integrity of the technological system increased from 0.04 to 0.26, ie by 21%, due to the extremely high-frequency processing of cotton seeds.

Functional schemes for the use of monoethanolamine in the separation of gossypol from high-gossypol cottonseed oil and the use of urea solution in the gradual forfinization of gossypol oil are also reflected. The use of a solution of monoethanolamine and urea in the refining process has been shown to have a significant effect on improving the quality and yield of the oil.

DOI - 10.32743/UniChem.2022.93.3.13184
АННОТАЦИЯ

В данной статье представлены функциональная схема производства хлопкового масла высокой плотности с использованием ультравысокочастотной лучевой обработки хлопкового шрота, показатели стабильности и целостности производственных моделей операторной модели. Целостность технологической системы увеличилась с 0,04 до 0,26, т. е. на 21%, за счет чрезвычайно высокой частоты обработки семян хлопчатника.

Отражены также функциональные схемы использования моноэтаноламина при выделении госсипола из высокогоссиполового хлопкового масла и применения раствора мочевины при поэтапной форрафинации гossиполисольного масла. Показано, что использование раствора моноэтаноламина и мочевины в процессе рафинирования оказывает значительное влияние на улучшение качества и выхода масла.

Keywords: monoethanolamine, forrafination, cottonseed oil, gossypol, acid count, ultra-high frequency rays, free gossypol, protein, amino acid, hydration.

Ключевые слова: моноэтаноламин, форрафинат, хлопковое масло, госсипол, кислотность, ультравысокочастотные лучи, свободный госсипол, белок, аминокислота, гидратация.

Introduction. Fatty raw materials contain substances that act as raw materials for several other industries, such as oil and protein. In particular, cottonseed contains the valuable raw material for the medical and pharmaceutical industries, namely gossypol. Based on Gossypol, various drugs for difficult-to-treat diseases are produced, which are in great demand all over the world. Today's traditional technology for extracting cottonseed oil is designed to separate the oil as much as possible by force-extraction, in which gossypol is mainly transferred to the composition of the husk. Also, by binding to various components in the core, the toxicity of gossypol is reduced [1]. This technology does not allow to separate the gossypol in the native state because when the mill is treated hydrothermally in humidifying-evaporating augers and frying pans, the main part of it loses its nativity and remains in contact with the protein in the casing. In this case, the main part of free gossypol is bound to the proteins, carbohydrates, amino acids and other stable structural components of the cell.

Materials and methods. Based on laboratory and experimental research, we have developed a new high-frequency processing technology for the production of high-pressure cottonseed oil instead of moisture-heat treatment in a six-grain frying pan for cottonseed meal. To give a clear example and present the physicochemical nature of our proposed technology, we have developed its operator model. In it, each element reflects a defined sample process and demonstrates the interaction of input material and energy flows with output currents. Based on the operator model of the proposed technology for the production of high-pressure cottonseed oil, it is possible to distinguish between the main and auxiliary process operators, as well as the directions of recirculation of material and energy flows. Based on the developed operator model, it is possible to model the structure of the technological system of processing of cotton seed pulp using ultra-high frequency beams and perform a systematic analysis and synthesis of the scheme under consideration [2].

Operator models of treatment of oil with monoethanolamine for separation of technical gossypol from isolated high gossypol cotton oil and treatment with urea solution for complete purification of gossypol from the obtained oil have been developed. With the help of the developed operator model, it was possible to improve the technology of separation of technical gossypol and oil refining. Based on the operator model, the modelling of the structure of the technological systems of extraction and refining of technical gossypol and the synthesis of the process, i.e. the theoretical and practical analysis of the process were analyzed. The operator model implies the use of three basic concepts: input, process, and output, i.e., a combination of quantitative and qualitative descriptions that define a particular technological system of production.
Figure 1. Functional scheme of high gossypol press cotton oil extraction technology

The technology developed for the production of high-gossypol press cottonseed oil using ultra-high-frequency light processing requires the application of many functional technological operations. Figure 1 shows a functional diagram of the technology developed for the production of high-gossypol cotton oil by grinding using ultra-high-frequency processing.

As can be seen from Figure 1, the proposed technology for obtaining high-gossypol press cottonseed oil consists of 8 functional operations covering various technological processes. Imaging them by separate operator models allows revealing their physical and physicochemical nature, to identify the same types of processes and their interaction in the topology of the developed technological scheme [3-5].

Figure 2. Operator model of high-frequency cottonseed oil extraction technology using ultra-high-frequency processing

Figure 2 shows the operator model of the technology for obtaining high-gossypol cottonseed oil by ultra-high-frequency processing. As can be seen from Figure 2, the proposed model includes technological operators for complex chemical changes, phase shifts, mixing and separation. In addition, auxiliary process operators such as heating, cooling and compression are often used. It is known that the rational method of synthesizing a technological system is to develop an operating model based on its objectives and subsystems. In our example, subsystems have the following objectives:

A - high gossypol press cotton oil cleaning;
B - pressing of cotton with high gossypol;
C - ultra-high frequency processing of cotton yarn;
D - Grinding of cotton seeds.
The operator's model differs from the traditional model in that the C-system, i.e., high-frequency processing of the cotton mill, transfer of the fuze from the sub-system A to the B-system before pressing the roast, as well as the moisture-heat treatment of the mill are sharp. Lack of steam transmission line. All these changes have made it possible to process cottonseed in "soft" modes and increase the amount of gossypol in the obtained press oil [6-9].

It is known that the main technical definition of such processes is stability as a factor of system integrity. Here, the concept of stability has a broader meaning than the concept of stagnation. A process of the same rhythm is a process of stagnation that has changed to a certain extent and has reached a peaceful rhythm. At the same time, stagnation characterizes the quality of the system's performance and level of development. Hence, the stability of a subsystem of a technological system is evaluated by an indicator shown in the following example for a binary subsystem (a subsystem with two possible states of the process on a parameter that is important for the next subsystem state):

\[ \eta_i = \frac{1 - H_i}{1}; \]  

(1)

There, \( \eta \) - stability and entropy of a number subsystem

The degree of integrity of the technological system under consideration can be calculated as follows:

\[ \theta_{ДСВА} = \eta_A + \eta_B/C + \eta_C/D + \eta_A/C + \eta_C - 3 \]  

(2)

The type of formula for calculating the degree of integrity of a system is determined by the number of subsystems and their structure. Both the stability of small systems and the integrity of the processing system are measured in relative units (bits/bits). Moreover, the main condition for the description of this technological system is to ensure that it is \( 0 < \eta_i < 1.0; \) \( 0 < \theta_i < 1.0. \) Table 1 shows the results of calculating the stability and integrity of the studied technologies for the production of cottonseed oil [3-7].

**Table 1.**

<table>
<thead>
<tr>
<th>The name of the technological system</th>
<th>Indicators of small system stability</th>
<th>System integrity (0)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traditional technology of cottonseed oil production (control)</td>
<td>( \eta_A ) 0.77 ( \eta_B/C ) 0.69 ( \eta_C/D ) 0.78 ( \eta_A/C ) 0.80</td>
<td>0.04</td>
</tr>
<tr>
<td>High gossypol oil production technology using ultra-high frequency processing of cotton seed pulp (experiment)</td>
<td>( \eta_A ) 0.79 ( \eta_B/C ) 0.81 ( \eta_C/D ) 0.84 ( \eta_A/C ) 0.82</td>
<td>0.26</td>
</tr>
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</table>

As can be seen from Table 1, the stability of the “S” subsystem increased from 0.69 to 0.81 due to the very high-frequency processing of the crusher (instead of the traditional six-pan frying pan). This had a positive effect on the performance of the next sub-systems V and A. In general, the integrity of the technological system increased from 0.04 to 0.26, i.e., by about 21%, due to the extremely high-frequency processing of the grind.

The low stability of a traditional six-pot frying pan can thus be explained. In it, along with convective heat exchange, the high-pressure steam transmitted to the inside of the apparatus dramatically changes the quality of grinding. Proteins are digested, several complex physicochemical processes occur in which gossypol forms complex compounds with proteins, phospholipids and other substances. Uneven heating of the material leads to over-frying of the grinder on the one hand, and under-frying on the other. All this has a negative impact on the quality of the oil and kunjara obtained.

Studies have shown that ultra-high frequency machining of the material allows the material to be heated uniformly over its entire volume by the induction method. In addition, there is no need to raise the crushing temperature above 75 °C, which minimizes the formation of gossypol derivatives in the crushing. In addition, the very high-frequency processing of the grinding increases its ability to open pores that are difficult to extract and to extract oil, gossypol and other substances from them [10-12].

It is important to separate gossypol from high-gossypol cotton oil, which serves to separate gossypol with a high content of gossypol as a separate commodity and to establish a technology of full-cycle refining of gossypol oil. When using the oil extracted from gossypol for technical purposes or refining it qualitatively to the level of edible oils, it is necessary to process the oil sequentially from all technological processes of refining. The following figure shows a functional diagram of the technical gossypol extraction and high-gossypol oil refining technology from high-gossypol cotton oil.

It will be necessary to develop an operator model of technological processes in the organization of technical gossypol separation technology through step-by-step filtration of degassed oil and processing of the obtained fraction.
As can be seen from Figure 3, the technology of obtaining technical gossypol from high-gossypol cottonseed oil and the stepwise fortification of the oil is conditionally divided into 7 small technological processes. These are 1-process of obtaining gossypol degreased oil and gossypol monoethanolamine fraction by treatment of high-gossypol cotton oil with monoethanolamine; 2-The process of using urea solution in the alkaline refining of degassed oil; 3-Adsorption refining process; the 4-The process of exposure of Gossypol to a monoethanolamine derivative of sulfuric acid; 5-Degreasing process of technical gossypol; 6- The process of distillation of Mistella; 7-Technical gossypol drying process. High gossypol cottonseed oil is first processed with monoethanolamine in process 1. As a result, 2 fractions are formed, i.e. gossypol degreased oil and gossypol with monoethanolamine. When it comes to this part, the functional scheme is divided into two major technological processes [12-15]. In this case, the decomposed oil is processed separately in the refining stages of the technological process. The main difference between the proposed technological scheme from the traditional technological scheme is the use of urea solution instead of water in the alkaline refining of oil. Therefore, this technological process is defined separately as technological process 2. Subsequent technological processes of the refining process are generally defined as a single technological process. These sub-processes of the refining process are proposed and carried out uniformly in traditional technology [16-18].

The technological process of separation of technical gossypol from the monoethanolamine derivative of the second fraction gossypol obtained by treatment of high-gossypol cotton oil with monoethanolamine was conditionally divided into 4 technological processes. In process 4, the monoethanolamine compound of gossypol is returned to gossypol by treating the product with sulfuric acid. We know that monoethanolamine also interacts with free fatty acids in fats. When treated with sulfuric acid, the compounds of free fatty acids formed with the monoethanolamine are also reacted with the acid and returned to the fatty acid. Separation of fatty acids from the resulting mixture of technical gossypol and fatty acids in the process of degreasing technical gossypol, ie process 5. During the degreasing process, it is necessary to use a solvent that does not act as technical gossypol in the purification of fatty acids and various other compounds. Extraction gasoline was used as such a solvent. The oil and fatty acids in technical gossypol dissolve in extraction gasoline to form mistella. The mistella formed for reuse of the extracted gasoline in the technological process is transferred from the distillation process to 6.1 processes. In order to obtain technical gossypol with a high content of native gossypol from the degreased technical gossypol, process 5.1 technical gossypol is dried and sent for storage.

**Conclusion.** In summary, the technology developed for the production of high-gossypol press cottonseed oil, its operator model and the principal processes outlined in the functional schemes for the separation of gossypol from high-gossypol oil and stepwise forrification of oil...
serve as a basis for technological improvement and optimization. Exposure of cotton seed pulp to ultra-high frequency rays minimizes the formation of complex bonded derivatives of gossypol in hydrothermal treatment. A significant reduction of energy consumption compared to traditional technology is achieved, improving the quality of the extracted oil.

The use of monoethanolamine in the separation of gossypol from high-gossypol cottonseed oil and the use of urea solution in the gradual faraffination of gossypol degassed oil has a significant impact on improving the quality and yield of oil.

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