

Research on the refining and decolorization process of segmented tallow

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ABSTRACT

Using segmented tallow as the experimental material, processed to obtain segmented tallow, and exploring the refining and decolorization process of segmented tallow. Firstly, the orthogonal experimental analysis method was used to investigate the effects of three single factors, namely heating temperature, heating time, and heating speed, on the sensory perception of refined segmented tallow; Secondly, study the decolorization effect of silica gel, activated clay, and attapulgite as decolorizing agents on the segmentation of tallow. The optimal conditions of decolorizing agent for segmenting tallow and oil were systematically investigated from the aspects of decolorizing agent dosage, decolorizing temperature, and decolorizing time. The results showed that under the same conditions, the decolorizing effect of activated clay was the best; Finally, response surface methodology was used to investigate the optimization of three single factors, namely the amount of decolorizing agent, decolorization temperature, and decolorization time, on the decolorization of segmented tallow and fat, in order to obtain the optimal decolorization conditions. The experimental results show that the optimal refining conditions are: heating temperature of 165°C, heating time of 85 minutes, and heating speed of 510 r/min. After sensory evaluation data, the optimal sensory score obtained under these refining conditions is 8.6; Under the conditions of active clay dosage of 3.7%, decolorization temperature of 81°C, and decolorization time of 17 minutes, the decolorization rate of segmented tallow can reach 71.9%.

KEYWORDS

Split tallow; Refine; Decolorization process; Response surface optimization

1. INTRODUCTION

1.1 Tallow and its chemical composition

1.1.1. Overview of tallow

At present, edible animal fat mainly includes edible pig fat, edible tallow, edible mutton fat, etc., it is a solid or semi-solid fat extracted from animal fat tissue such as pigs, cattle, sheep, etc., refined into a kind of lipid products, with irreplaceable meat fat aroma, compared with ordinary vegetable oil, although its saturated fatty acid content is higher, but it also contains a variety of fatty acids, has a certain nutritional value, can bring high energy to the body, so it is an indispensable raw material in the food industry, in the cold food industry, It has a wide range of applications in pastry and other industries.

As a kind of animal fat, tallow is white in color, odorless, and contains a variety of fatty acids, rich in nutrition, so it is commonly used to produce margarine, tallow biscuits and other foods. However,

the tallow in the slaughterhouse, because of the harsh slaughtering environment, or the transportation time is relatively long, as well as the influence of various storage environments such as climate, under normal circumstances, there will be some oils and fats that are hydrolyzed into free fatty acids and glycerol, and a small number of unsaturated glycerides, such as oleates, will also be oxidized to aldehydes and small molecule acids and other foul-smelling substances. Impurities such as organic matter, which greatly reduces the quality of the tallow, making it inedible directly. Therefore, before it is applied to the food industry, it needs to be refined to remove hydrolysis and oxidation products, such as acids, solid impurities, dust, etc. When developing tallow products, increasing the "milky flavor", "fresh flavor", and "meat flavor" of the product can improve consumer preference [1].

1.1.2. The main components of tallow

Tallow contains fatty acids, vitamins, minerals, cholesterol, and other ingredients. Fatty acids are the main nutrients in tallow and are in high levels [2]. Fatty acid composition of tallow: palmitic acid 25%~32.5%, stearic acid 14.1%~28.6%, myristic acid 2%~7.8%, oleic acid 38.9%~49.6%, linoleic acid 1.1%~5%. Unsaponifiable substances are less than 1%. Tallow is a solid fat with an irreplaceable and unique flavor that can increase appetite and is widely used in the food processing industry [3].

1.2. Refining of tallow

Tallow is a kind of animal fat, which is generally extracted from the fat tissue of cattle, and the common tallow is mainly made of sirloin oil, tallow plate oil, segmentation oil and intestine oil, and the tallow extracted from different parts is different in terms of flavor and taste. Refining tallow is generally to clean the raw materials first, remove impurities, and then use the boiling pot or boiling tank and other equipment to boil, melt the beef fat, and then filter, cool, solidify, and package, which is the tallow bought on the market. Segmentation oil is a summary of fragmented subcutaneous tissue and fat that has been divided and removed, piece by piece, of uneven size and relatively fragmented bovine fat (usually with lean tissue and blood). Segmented oil is a combination of meat, fat, face, milk, and oil residue, and has a special and irreplaceable flavor, so segmented tallow is selected for the optimization of the refining process [4].

1.3 Decolorization of tallow

1.3.1. Decolorization method of tallow

Tallow is supposed to be colorless, but due to the mixing or production of pigmenting substances during processing or storage, it has a darker color, which affects its use in the food industry and reduces the quality of the oil, for which the oil is decolorized [5]. The commonly used decolorization methods include physical adsorption method and chemical method (oxidation, reduction, acid refining and photochemical method), and the most widely used in industry is physical adsorption. In actual production, activated clay [6] is often used as an adsorbent due to its good chemical activity and large adsorption pore volume, strong adsorption force for pigments and impurities, and high decolorization rate, low oil carrying rate, and fast filtration speed. In the decolorization of activated clay, the amount of activated clay is the main factor affecting the adsorption effect. In the process of oil decolorization, the use of adsorbents can have a huge impact on the quality of oils and fats, including trans acids and oil unsaturation, as well as the destruction of polyene fatty acids such as linoleic acid and linolenic acid, and determining the optimal conditions for the decolorization process can improve the quality of oils and fats [7].

1.3.2. Decolorization process of tallow

Decolorization process of tallow:

Tallow → melted → decolorizing agent added → heated, stirred → centrifuged → cooled → bagged

1.4 Physical indicators of tallow

As the most representative physical indicator of oil, color directly reflects the external quality characteristics of oil. Each oil has its own unique color, and as the processing conditions change, the index changes significantly, thus reflecting the corresponding quality change. Starting from the physical index of color, the color change of tallow under different decolorizing agent treatments was studied, in order to illustrate the effect of decolorization on the sensory quality of oil.

1.5 Purpose and Significance of the Study

Tallow is widely used in bakery products, dairy products, hot pot bases, etc. [8] because of its bright color, mellow taste, and stable processing performance, giving it a crispy taste and adding flavor and color to hot pot bases. Especially in the Sichuan-Chongqing region, as the main raw material of hot pot base [9], the quality of tallow will directly affect the quality of spicy tallow hot pot. The purpose of this study is to improve the refining and decolorization process and improve the quality of tallow.

1.6 Research Content

In this paper, the refining and decolorization process was improved by using segmented tallow as raw material.

The main research contents of this paper are as follows:

(1) Research on the refining process of segmented tallow

The range of refining process was determined by single factor tests (heating temperature, heating time, heating speed), and the optimal refining condition range was screened out based on sensory scores. On this basis, an orthogonal test was designed to compare the effects of different factors on the sensory quality of segmented tallow, and the optimal refining process conditions were obtained.

(2) Research on the decolorization process of segmented tallow

Taking the segmented tallow obtained in (1) as a sample, the optimal condition range of the decolorization process was screened by the amount of decolorizing agent, the decolorization temperature and the decolorization time, and the decolorization rate of the decolorization obtained oil sample was determined to obtain the optimal decolorization condition range. Through the optimization of the response surface, the decolorization conditions were determined, and the optimal decolorization scheme was obtained.

2. MATERIALS AND METHODS

2.1. Raw materials, reagents and instruments

2.1.1. Experimental raw materials

The raw materials used in this experiment were fresh and high-quality segmented tallow, which was cut into pieces, washed and minced after removing the meat and fascia, and made into a uniform sample of 100 g per portion.

2.1.2. Experimental reagents

Silicone oil (food grade), activated clay (food grade), attapulgit (food grade), silica gel (chemical pure).

Table 1. Experimental instruments and equipment

instrument	Model	factory
Electronic analytical balances	AL104	METTLER TOLEDO Instruments Ltd
Collector type thermostatic heating magnetic stirrer	DF-101S	Shanghai Lichen Bangxi Instrument Co., Ltd
Digital thermostatic water bath	DRHH-S6	Shanghai Chengjie Instrument Equipment Co., Ltd
Meat grinder	MLMQYJR09BLWSD	Hunan Yangzi Intelligent Technology Co., Ltd
Refrigerator	BCD-471WDCD	Qingdao Haier Co., Ltd
Visible spectrophotometer	722S	Shanghai Prism Technology Co., Ltd
Spectrophotometer	YS3010	Guangdong Sanenshi Intelligent Technology Co., Ltd
centrifuge	SR-800	Changzhou Surui Instrument Co., Ltd

2.2. Segmentation tallow refining and decolorization process

2.2.1. Segmentation of tallow refining and decolorization process

After removing the meat and fascia, cut the tallow into small pieces, wash it, dry the water, grind it with a meat grinder, put it in the refrigerator for later use, and set aside.

The refining and decolorization process is as follows:

Cut tallow → cut into small pieces → wash → crush → melt → refining → filter → decolorize → finished product

2.2.2. Divide the key points of tallow refining and decolorization

Cutting and cleaning: After removing the lean tissue, blood and fascia on the tallow, cut it into small pieces of about 1cm, wash it, control the moisture, and set aside.

Stirring: Grind the divided tallow into a uniform sample with a meat grinder, bagged and refrigerate for later use.

Melting: Weigh a certain amount of divided tallow, put it in a constant temperature water bath at 70 °C, melt it for a period of time before refining.

Filtration: The refined tallow is filtered out of the oil residue with gauze, slightly cooled and then bagged, and frozen in the refrigerator for later use.

Decolorization: Put the decolorizing agent into the refined oil sample, and determine the optimal decolorization conditions by controlling the amount of decolorizing agent, decolorization temperature and decolorization time.

Centrifugation: Since the freezing point of tallow is very low and will solidify quickly at room temperature, it is necessary to centrifuge as soon as possible after decolorization is completed, and store the decolorized tallow in bags.

2.3. Determination of the segmented tallow refining process

2.3.1. Single factor test of split tallow refining

Three variables: heating temperature, heating time, and heating speed were selected, and a single factor experiment was carried out, and 10 evaluators with sensory evaluation ability were selected to score the oil according to the sensory scoring criteria in Table 3.

(1) Heating temperature

Weigh 4 portions of divided tallow into 100 g and heat at 100°C, 120°C, 140°C and 160°C. Organoleptic evaluations are carried out to select the optimal heating temperature for follow-up tests.

(2) Heating time

Weigh 4 parts of split tallow, set the total amount of split tallow for each part is 100 g, and the heating time is 40 min, 60 min, 80 min and 100 min. Organoleptic evaluation was carried out to select the optimal heating time for follow-up tests.

(3) Heating speed

Weigh 4 parts of split tallow, set the total amount of split tallow for each part to 100 g, and heat at 250 r/min, 500 r/min, 750 r/min and 1000 r/min. A sensory evaluation is carried out to select the optimal heating speed for follow-up tests.

2.3.2. Orthogonal experimental design for segmentation of tallow refining

Based on the results of the single factor test in 2.3.1, the L9(3⁴) orthogonal experimental design was performed on the three single factors, and the specific factor levels are shown in Table 2.

Table 2. Orthogonal Experimental Factor Levels

level	A: Heating temperature (°C)	B: Heating time (min)	C: Heating speed(r/min)
1	155	75	490
2	160	80	500
3	165	85	510

2.3.3. Segmentation of tallow sensory assessment methods

Taking the sensory score as the criterion for determining the optimal segmented tallow refining process [10], 10 sensory evaluators were randomly selected from different populations to objectively evaluate the four aspects of segmented tallow and fat: color, tissue status, smell and taste, and impurities, as shown in Table 3, and fill in Table 4 oil quality score sheet.

Table 3. Grease Sensory Scoring Criteria

project	index
Color	It is white when solidified, yellowish when melted, clear and transparent.
Organizational status	The tissue is delicate and ointment-like.
Smell and taste	It has the inherent fragrance and taste of tallow, and there is no rancid taste.
impurity	No foreign impurities are visible to the naked eye.

Table 4.Grease Quality Score Card

Flavor quality evaluation			
date		Evaluators	
Total Intensity Score: The total flavor quality of the sample is rated on a 10-1 scale			
		Total Quality Score	
quality	1	2	3
10 fabulous	_____	_____	_____
9 good	_____	_____	_____
8	_____	_____	_____
7 medium	_____	_____	_____
6	_____	_____	_____
5 difference	_____	_____	_____
4	_____	_____	_____
3 very poor	_____	_____	_____
2	_____	_____	_____
1 range	_____	_____	_____

2.4. Segmentation Tallow Decolorization Experiment

2.4.1. Determination of decolorizing agent

The decolorization of the segmented tallow was carried out by activated clay adsorption method, attapulgit adsorption method, and silica gel adsorption method [11], and the dosage of decolorizing agent was 2%, and the best decolorizing agent was selected from the experimental results.

2.4.2. Optimization of the decolorization process

The response surface method was used to optimize the decolorization process of segmented tallow [12]. The influencing factors [13] were the amount of decolorizing agent (X1), the decolorization temperature (X2) and the decolorization time (X3), and the response value was the decolorization rate (Y).

Table 5. Response surface analysis test factor codes and level tables

factor	Encoded values		
	-1	0	1
X ₁ (Dosage of decolorizing agent)%	3	4	5
X ₂ (Decolorization temperature)/ °C	80	85	90
X ₃ (Destaining time)/min	10	15	20

2.4.3. Methods for determining decolorization

The absorbance was measured and the oil decolorization rate was calculated by using deionized water as the reference solution at an absorption wavelength of 520 nm and a 1 cm cuvette [14]. The decolorization rate is calculated as follows:

$$\text{Decolorization rate} = [(A_0 - A) / A_0] \times 100\% \quad (1)$$

Where: A_0 and A are the absorbance of the tallow before and after decolorization, respectively.

2.4.4. Determination of color

The color of the grease samples was determined by a colorimeter [15]. After the samples were heated in an 80°C water bath for 10 minutes, L^* , a^* , and b^* were measured and recorded. L^* is the lightness index, which refl

ects the change of oil from black (-) to white (+), a^* and b^* are the chroma index, a^* reflects the change of oil from green (-) to red (+), and b^* reflects the change of oil from blue (-) to yellow (+). Each group of samples was measured 3 times in parallel. The color difference (ΔE) of tallow is calculated according to the following formula.

$$\Delta E = (\Delta L^{*2} + \Delta a^{*2} + \Delta b^{*2})^{1/2} \quad (2)$$

Where:

ΔL^* is the change in brightness of tallow after decolorization and whiteboard (or before decolorization);

Δa^* is the red/green change of tallow after decolorization and whiteboard (or before decolorization);

Δb^* is the change in yellow/blue between tallow and whiteboard (or before decolorization) after tallow decolorization.

3. RESULTS & ANALYSIS

3.1 Analysis of single factor test results of segmented tallow refining

3.1.1 Determination of heating temperature

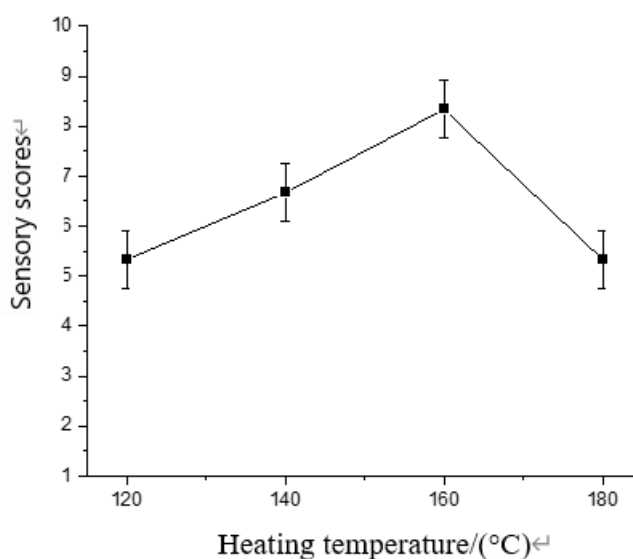


Figure 1. Effect of heating temperature on sensory scores

As can be seen from Figure 1, when the heating temperature is 160°C, the sensory evaluation is the highest, which is 83 points. As the heating temperature rises, the fishy smell of the oil lessens. At a heating temperature of 160°C, a hint of nutty and creamy flavor appeared, and this heating temperature was selected for the following experiment.

3.1.2. Determination of heating time

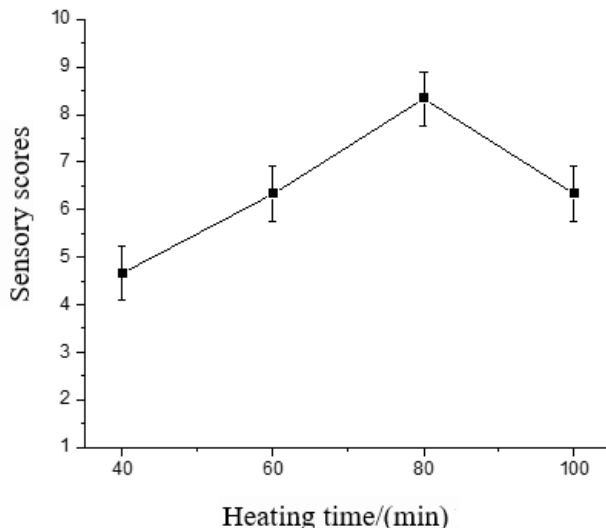


Figure 2. Effect of heating time on sensory scores

As can be seen from Figure 2, when the heating temperature remains unchanged, the sensory evaluation value increases first and then decreases with the increase of heating time. When the heating time is 80 min, the sensory evaluation value reaches the maximum. Through the analysis, it is found that there is an optimal value for the effect of heating time on sensory evaluation, that is, when the heating time is 80min, the sensory evaluation of heating time is the highest. At this time, the refined tallow has no obvious peculiar smell, has a fragrance, and the color is yellowish, clear and transparent. If you increase the heating time, the tallow will have a slightly bitter taste. The heating time was selected to be 80 minutes for the following test.

3.1.3 Determination of heating speed

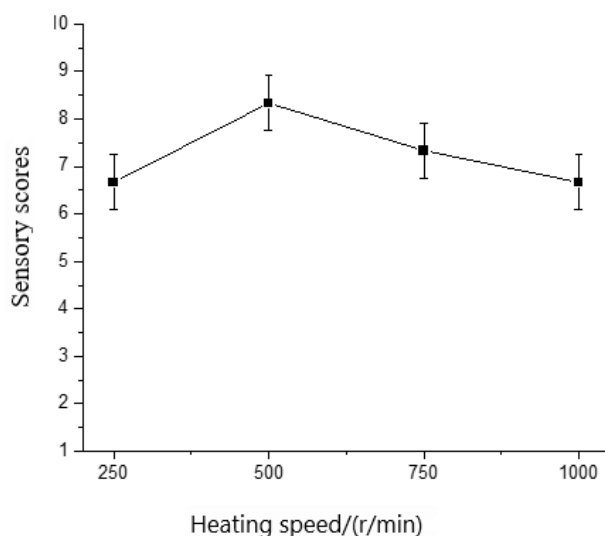


Figure 3. Effect of heating speed on sensory scores

As can be seen from Figure 3, the effect of heating speed on the sensory evaluation of segmented tallow does not fluctuate much, and the sensory evaluation of segmented tallow increases first and

then decreases with the increase of heating speed. There is an optimal value for the effect of heating speed on sensory evaluation, that is, the highest sensory value is obtained when the heating speed is 500r/min. At this time, the split tallow has an oily fragrance, the color is slightly yellow, and there are no impurities visible to the naked eye.

3.2 Orthogonal test results of segmented tallow

Based on 31 The results of the single variate test were orthogonal for the corresponding range of the three single factors, and the results and range analysis are shown in Table 6.

Table 6. Orthogonal experimental results

Test number	factor			Sensory scores
	A: Heating temperature(°C)	B: Heating time (min)	C: Heating speed (r/min)	
1	1	1	1	6.38
2	1	2	2	6.5
3	1	3	3	7.75
4	2	1	2	7.19
5	2	2	3	7
6	2	3	1	7.56
7	3	1	3	8
8	3	2	1	8
9	3	3	2	8.5
K1	20.63	21.57	21.94	
K2	21.75	21.5	22.19	
K3	24.5	23.81	22.75	
k1	6.877	7.190	7.313	
k2	7.250	7.167	7.397	
k3	8.167	7.937	7.583	
R	1.290	0.770	0.270	

The orthogonal test results in Table 6 show that the order of action of each factor is $A > B > C$. The relationship between the horizontal values of each factor is as follows: $A_3 > A_2 > A_1$, $B_3 > B_1 > B_2$, $C_3 > C_2 > C_1$. The influence order of each factor on the segmented tallow can be evaluated, and the heating temperature has the greatest influence on the segmented tallow, while the influence order of heating time and heating speed decreases in turn. Based on this refining condition, a validation test was carried out again, under which the sensory score of 8.6 was achieved under the following conditions: the heating temperature was 165°C, the heating time was 85 minutes, and the heating speed was 510 r/min.

3.3 Test results of decolorization rate of segmented tallow

3.3.1. Determination of decolorizing agent

Table 7. Effect of different decolorizing agents on the decolorization effect of segmented tallow

	Decolorization rate	Chromatic aberration (whiteboard)	Chromatic aberration (before decolorization)
Activated white clay	41.43%	68.75	6.48
attapulgate	22.57%	70.5467	5.55
silica gel	71.20%	71.1467	3.84667

Tallow fat, which is supposed to be colorless, has a darker color due to the mixing or production of pigmenting substances during processing or storage, which affects its use in the food industry and reduces the quality of the oil. After decolorization, the color of the oil changes significantly from yellow to white, and the content of pigments becomes lower [16]. As can be seen from Table 7, the decolorization effect of the three decolorizing agents on the segmented tallow was in the order of silica gel > activated clay > attapulgate, combined with the total color difference of the three decolorizing oils, and the activated clay was selected as the best decolorizing agent for the segmentation of tallow.

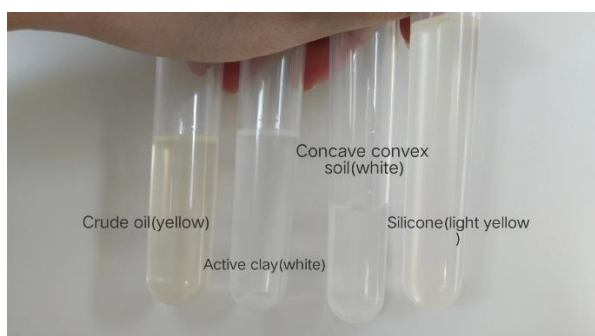


Figure 4. Decolorization effect of different decolorizing agents

3.3.2 Determination of the amount of decolorizing agent

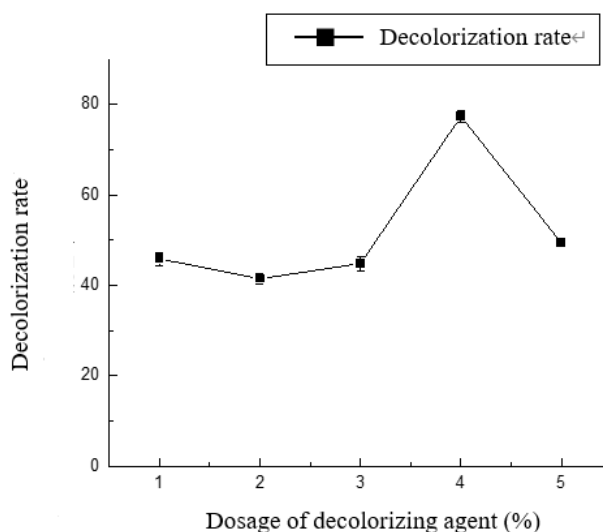


Figure 5. Effect of decolorizing agent dosage on decolorization rate

The amount of decolorizing agent is one of the important influencing factors in the decolorization process, the amount of decolorizing agent is too small, the effect of decolorization can not be achieved,

and the amount of decolorizing agent is too much, which will not only make the oil loss rate too high and waste the decolorizing agent, so it is very important to determine the appropriate amount of decolorizing agent for the decolorization process. Under the conditions of decolorization temperature of 85°C and oscillation speed of 400 r/min, activated clay with different mass fractions was selected as decolorizing agent to decolorize the segmented tallow, and the results are shown in Figure 5. As can be seen from Figure 5, the decolorization rate of split tallow increases with the increase of the amount of activated clay, and the decolorization rate of the split tallow reaches the maximum value when the dosage of activated clay is 4%. Therefore, the dosage of activated clay was selected to be 3%-5% for response surface optimization.

3.3.3 Determination of decolorization temperature

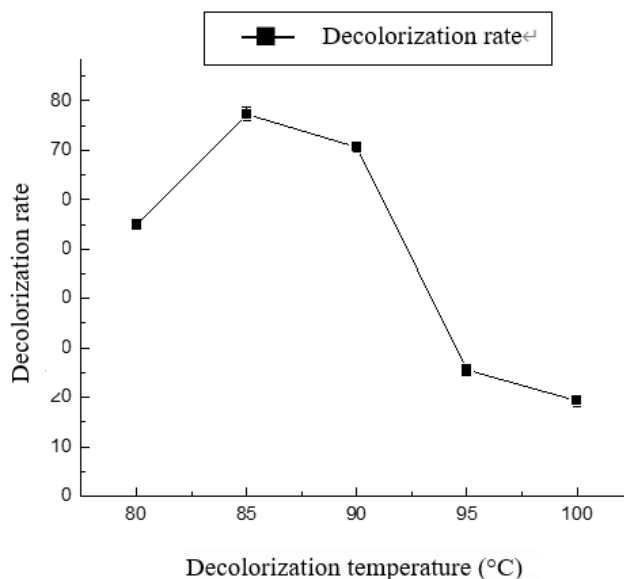


Figure 6. Effect of decolorization temperature on decolorization rate

As can be seen from Figure 6, the decolorization rate of split tallow increases and then decreases with increasing temperature. When the temperature reaches 85°C, the decolorization rate reaches the maximum, but after the temperature exceeds 85°C, the decolorization rate decreases with the increase of temperature. The increase of decolorization temperature increases the activation energy of pigment molecules in oil, increases the movement rate of these pigment molecules in oil, and increases the chance of encounter with decolorizer, which is conducive to being adsorbed by decolorizer, thereby improving the decolorization rate, but when the temperature continues to rise, the adsorption capacity of decolorizer has reached the maximum, and the influence of temperature on decolorization rate is no longer obvious, so the decolorization temperature should be controlled at 80~90°C.

3.3.4. Determination of decolorization time

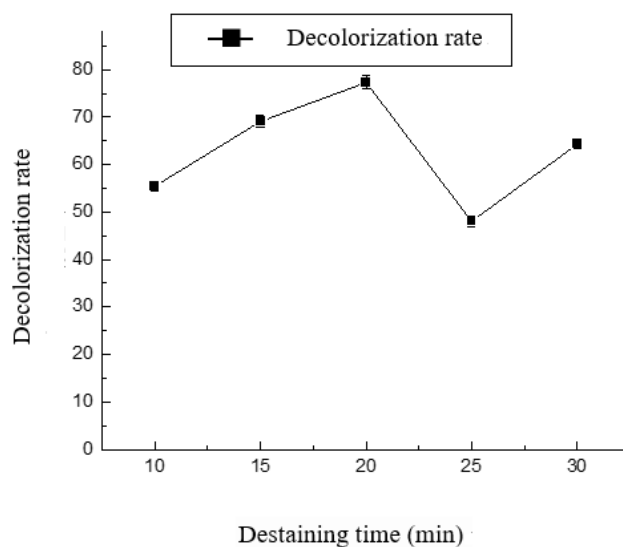


Figure 7. Effect of decolorization time on decolorization rate

As can be seen from Figure 7, the decolorization rate of segmented tallow is the highest when the decolorization time is 20 min. It takes a certain amount of time for clay to adsorb pigments, and because the active clay is acidic, the oxidation degree and acid value of the oil will increase with the extension of time. Therefore, it is necessary to control the decolorization time, and the production experience knows that the decolorization time of 15 ~ 20 min is appropriate [17], so the decolorization time of 10 ~ 20 min is selected for process optimization.

3.4 Optimization of decolorization process

3.4.1 Test results of segmented tallow response surface

On the basis of the single-factor test results, the amount of decolorizing agent, the decolorization temperature and the decolorization time were the influencing factors, and the decolorization rate of the segmented tallow was the response value, and the Box-Behnken experimental design was used to establish a mathematical model, and the response surface was analyzed to optimize the decolorization process conditions. The experimental design and data results are shown in Table 8, and the results of ANOVA are shown in Table 9.

Table 8. Box-Behnken trial design and results

Test number	X ₁	X ₂	X ₃	Decolorization/%
1	-1	-1	0	74.5
2	1	-1	0	62.1
3	-1	1	0	62.9
4	1	1	0	65.1
5	-1	0	-1	64.3
6	1	0	-1	63
7	-1	0	1	71.1
8	1	0	1	59.5
9	0	-1	-1	62.9
10	0	1	-1	62.1
11	0	-1	1	65.5
12	0	1	1	60.4
13	0	0	0	68.5
14	0	0	0	66.4
15	0	0	0	68.1
16	0	0	0	67.7
17	0	0	0	68.5

According to the test data in Table 9, the multiple regression equation was fitted, and the fitting formula for the decolorization rate on the amount of decolorizing agent (X₁), decolorization temperature (X₂), and decolorization time (X₃) was as follows: $Y=67.84-2.89 X_1-1.81 X_2+0.5250 X_3+3.65 X_1X_2-2.57 X_1X_3-1.08 X_2X_3+0.0300 X_1^2-1.72 X_2^2-3.39 X_3^2$.

Table 9. Response surface test results and ANOVA

Source of variance	Sum of squares	degree of freedom	mean square	F-number	P-value	Distinctiveness
model	243.65	9	27.07	33.99	<0.0001	**
X ₁	66.70	1	66.70	83.76	<0.0001	**
X ₂	26.28	1	26.28	33.00	0.0007	*
X ₃	2.21	1	2.21	2.77	0.1401	
X ₁ X ₂	53.29	1	53.29	66.92	<0.0001	**
X ₁ X ₃	26.52	1	26.52	33.30	0.0007	*
X ₂ X ₃	4.62	1	4.62	5.80	0.0468	*
X ₁ ²	0.0038	1	0.0038	0.0048	0.9469	
X ₂ ²	12.46	1	12.46	15.64	0.0055	*
X ₃ ²	48.53	1	48.53	60.94	0.0001	*
Residuals	5.57	7	0.7964			
Out-of-the-way items	2.54	3	0.8475	1.12	0.4407	
Poor purity	3.03	4	0.7580			
sum	249.22	16				
R ² =0.9776	R ² _{Adj} =0.9489	R ² _{Pred} =0.8178				
Adeq Preciso		21.8612				

Note: * is significant (P<0.05) and ** is extremely significant (P<0.01).

As can be seen from Table 9, in the case of model F=33.99, p<0.0001 indicates that the model is highly significant. When the misfit term F=1.12, p=0.4407>0.05, it means that the model is not significant. When the coefficient of determination R²=0.9776 and the correction coefficient R²_{Adj}=0.9489, this indicates that there is a good agreement between the measured and predicted values of the decolorization rate, indicating that the regression equation obtained can correctly analyze and predict the decolorization rate. In this model, the primary term X₁ and the secondary term X₁X₂ reached a very significant level, and the primary term X₂ and the secondary terms X₁X₃, X₂X₃, X₂² and X₃² also showed significant effects, indicating that the amount of decolorizing agent and the decolorization temperature had a significant effect on the decolorization rate of the segmented tallow, and this effect was not a simple linear relationship. From the F-value of the three factors, it can be concluded that the order of the factors affecting the decolorization rate of the segmented tallow is X₁>X₂>X₃, among which the amount of decolorizing agent has the greatest influence on the decolorization rate of the segmented tallow, followed by the decolorization temperature, and the decolorization time has the least impact. The analysis of variance showed that the interaction term X₁X₂ had a very significant effect on the response value, and the interaction terms X₁X₃ and X₂X₃ had a significant effect on the response value, indicating that there was a very significant interaction effect between the experimental factors X₁ and X₂, and there were significant interaction effects between factors X₁ and X₃ and X₂ and X₃. The results showed that the amount of decolorizing agent and the decolorization temperature had obvious effects on the decolorization rate of the segmented tallow, and the interaction between the amount of decolorizing agent and the decolorization temperature was obvious.

3.4.2. Analysis and optimization of the response surface diagram of segmented tallow

In order to study the effect of the various interaction conditions on the decolorization rate and total color aberration of the segmented tallow, the regression equation was calculated using the Design-Expert13 software. Figure 8 shows the 3D response surface and contour plots of the interaction conditions to better illustrate the effect of each variable on the response value. The Regression Equation was optimized by the Design-Expert 13 program to determine the optimal process for the three decolorization conditions to achieve the highest decolorization rate, and the optimal process parameters were 3.693% decolorizing agent dosage, 80.746°C decolorization temperature and 16.706 min decolorization time. Under these conditions, the decolorization rate of split tallow was 70.346%.

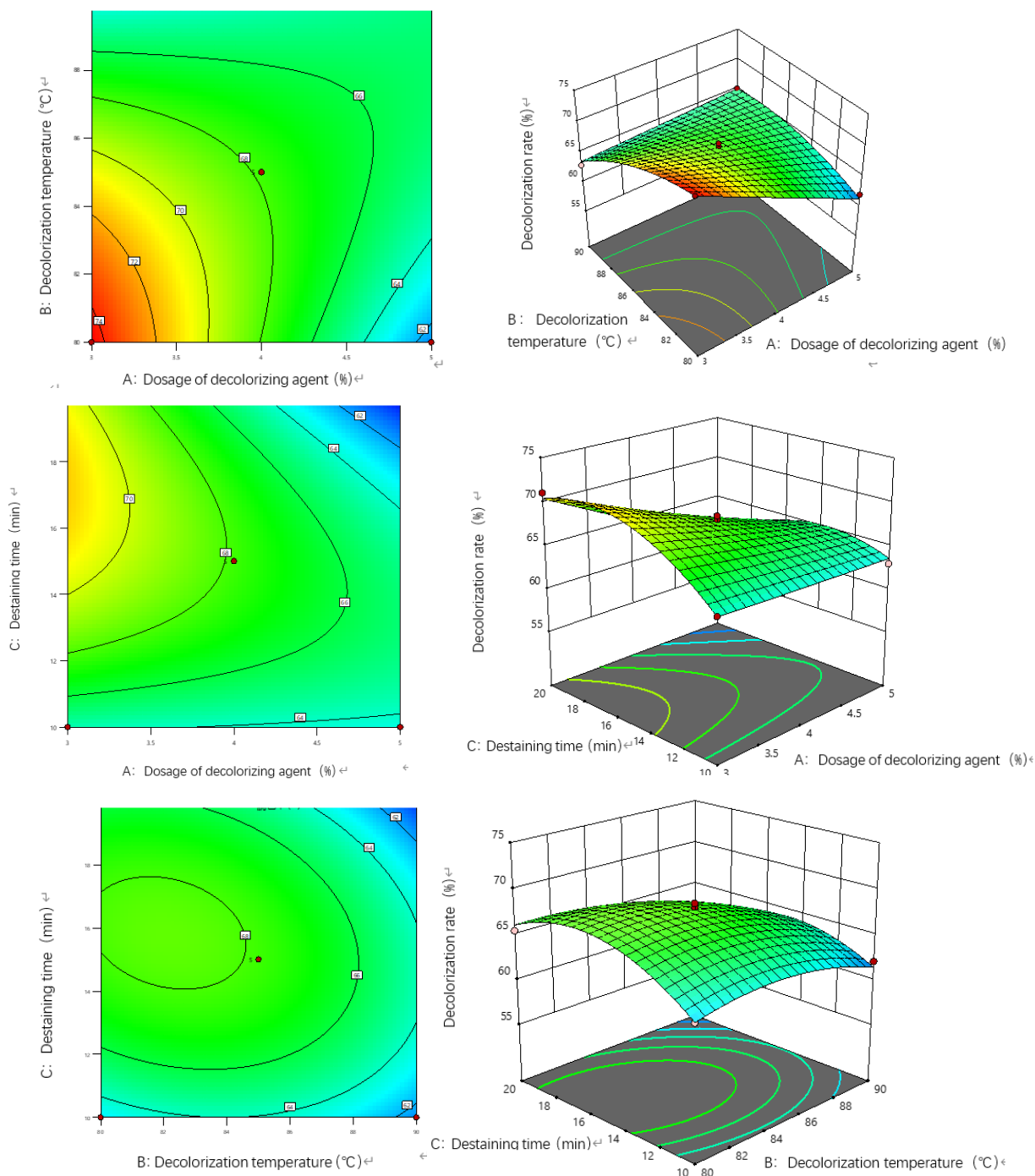


Figure 8. Contour and response surface diagram of the interaction of various factors

3.4.3 Validation test

Based on the mathematical model constructed, the parameters were optimized and analyzed by using the response surface software, and the process parameters were corrected to the amount of decolorizing agent 3.7%, the decolorization temperature of 81 °C, and the decolorization time of 17 min, considering the actual operability. In order to test the reliability of the results, three parallel verification experiments were carried out using the modified process parameters, and the decolorization rate of the segmented tallow was 71.9%, which was basically consistent with the theoretical prediction value, indicating that the reliability of this model could play a role in practical application.

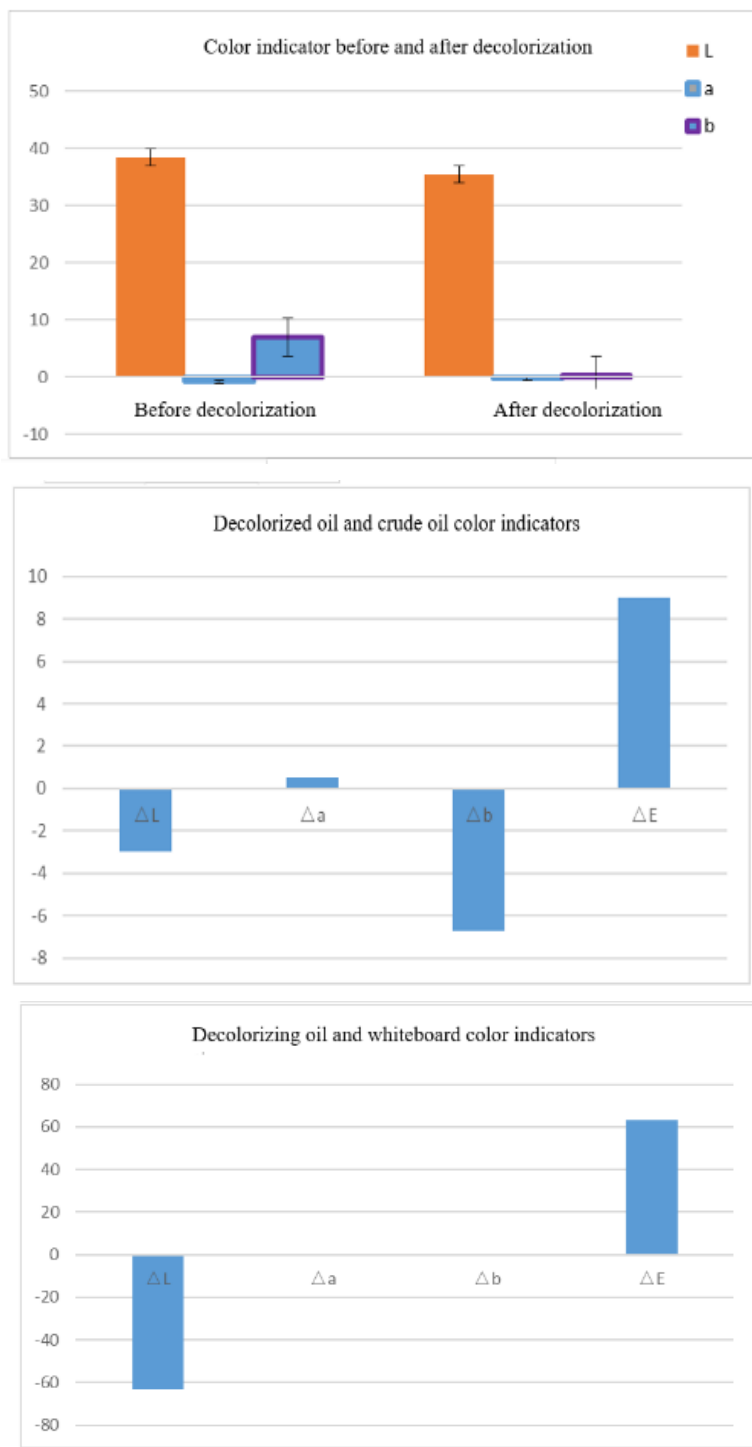


Figure 9. Tallow color changes

From Figure 9, it can be concluded that the L value of the segmented tallow before decolorization is 38.53, indicating that its color is bright and the brightness is white, and the a value is -0.73 and the b value is 6.97, indicating that the chroma is very weak, close to light yellow. For the situation after and before the decolorization of the tallow, as reflected in the direct reflection of the oil, the change range of L value is not very obvious, the brightness gradually dims, but the degree of change is not large, the change range of Δa value is very small, and the change of Δb value is very significant, which is negative, indicating that the color gradually changes to white compared with before decolorization. For the case of the decolorization of the tallow and the whiteboard, the difference between the ΔE value is relatively large, indicating that the brightness of the decolorized grease cannot reach the whiteness of the whiteboard, and the values of Δa and Δb are negative, indicating that the chroma is very low and white. The use of decolorizers improves the sensory quality of oils and reduces the presence of pigment substances, and the rational use of decolorizers is the key to improving the quality of oils.

4. CONCLUSION

4.1 Conclusion

In this study, split tallow was used as raw material, pre-treated, refined and decolorized. The effects of heating temperature, heating time and heating rate on the sensory of segmented tallow were determined by single factor test and orthogonal test, and the effects of decolorizing agent amount, decolorization temperature and decolorization time on the decolorization rate of segmented tallow were determined by response surface method, and the optimal refining and decolorization process parameters were finally obtained, and the results were as follows:

- (1) Through the single factor test and orthogonal test, the optimal process conditions for the refining of segmented tallow were as follows: heating temperature of 165°C, heating time of 85 min, heating rate of 510 r/min, preparation under these process conditions, and the sensory score of split tallow obtained was 8.6 points.
- (2) The optimal process conditions for the decolorization of segmented tallow obtained by the response surface method were as follows: the dosage of decolorizing agent was 3.7%, the decolorization temperature was 81°C, and the decolorization time was 17min, and the decolorization rate of the segmented tallow was 71.9%.

4.2 Outlook

With its unique flavor and high nutritional value, tallow is widely used in food production and industrial production, and has produced good economic benefits, so improving and improving the traditional tallow processing technology is very important to promote the rapid development of China's tallow processing industry. Therefore, strengthening the intensive processing of tallow and developing tallow products play a very important role in enhancing the added value of tallow and extending the tallow industry chain. In this paper, on the basis of the quality analysis of the segmented tallow, the sensory evaluation and decolorization rate were used as indicators, and the refining and decolorization processes were optimized to obtain the segmented tallow with good flavor and quality. However, there are also the following problems that need further research:

- (1) Although the sensory analysis method can reflect the quality of tallow to a certain extent, there is a certain degree of subjectivity, and more analysis methods can be considered to analyze the tallow more comprehensively.
- (2) Considering that there may be differences in the segmented tallow raw materials from different sources, the follow-up test can expand the range of sample sources and compare their process parameters to verify the universality of the process.

Through the above improvements and follow-up tests, the refining and process of segmented tallow can be improved more comprehensively and accurately, and a more reliable scientific basis for its application in actual production can be provided.

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REFERENCES

- [1] Wang Xuemei, Wang Chuanming, Liu Peng. Analysis of Sensory Characteristics of Tallow and Identification of Key Flavor Substances [J]. *China Oils and Fats*, 2023, 48(09): 30-6+59
- [2] Chen Weiyuan, Wang Fuchao, Zhang Hua. Molecular structure and oxidation stability of animal and vegetable oils and fats [J]. *Journal of Agronomy of Yanbian University*, 2021, 43(04): 63-8
- [3] Chen Yaqi, Li Jiancheng, Shu Shu, et al. Development of tallow blended frying oil and its frying performance [J]. *China Oils and Fats*, 2020, 45(10): 16-21+34
- [4] Yin Yongling, Deng Weize, Yuan Yongjun. Effect of refining conditions on plasticizers and flavor compounds in tallow [J]. *China Oils and Fats*, 2022, 47(12): 20-4
- [5] Zhang Wenlong, Huang Chengyi, Zhao Chenwei, et al. Research Progress on Pigments and Adsorption and Decolorization in Vegetable Oils [J]. *China Oils and Fats*, 2022, 47(06): 21-8
- [6] Chen Yan, You Mengyuan, Zhai Mengting, et al. Influencing factors of decolorization of activated clay in soybean oil [J]. *China Oils and Fats*, 2021, 46(07): 23-6
- [7] HENACHE Z, BOUKERROUI A, KASHI I. Modeling of the soybean oil bleaching and optimization of its conditions in the refining process for environmental interest [J]. *Nova Biotechnologica et Chimica*, 2018.
- [8] Bao Xinyu, Wang Lijin, Song Huanlu, et al. Analysis of the differences of aroma components between tallow and sheep fat based on electronic nose and GC-O-MS [J]. *Chinese Journal of Food Science*, 2022, 22(12): 267-81
- [9] ZHIXIANG K, LIZHI W, HUIYING W, et al. Effect of Dietary Fatty Acid on Fatty Liver, Carcass Performance and Body Fat Deposition in Landes Goose [J]. *China Poultry*, 2008.
- [10] Yang Xueyin. Quality evaluation of refined tallow, lard and intermediate fats and oils [D]; Tianjin University of Science and Technology, 2011
- [11] Li Wen, Yu Jun, Xie Chenwei, et al. The role of magnesium-silica-containing mixed decolorizing agent in the decolorization and drainage aid of anchovy oil [J]. *Food & Machinery*, 2023, 39(08): 166-74
- [12] Song Mingfa, Liu Xiaoyan, Zhang Qian, et al. Optimization of Decolorization Process of Tung Seed Oil by Response Surface Method [J]. *China Oils and Fats*, 2021, 46(05): 14-8
- [13] Peng Zhangwen, Ma Tian, Ma Haorui, et al. Study on decolorization process and decolorization effect of pecan oil [J]. *Agricultural Products Processing*, 2017, (10): 30-3+43
- [14] Wang Li, Liu Junbo, Hu Yaohui, et al. Optimization of decolorization process conditions of deer oil [J]. *Journal of Jilin Agricultural University*, 2012, 34(04): 454-8
- [15] Li Hanrun, Liu Xiong, Qin Xiaoli, et al. Effect of oil types on blended tallow flavor [J]. *China Oils and Fats*, 2022, 47(06): 53-61
- [16] Feng Lidian, Hao Ming, Zhang Wei, et al. Optimization of decolorization parameters and evaluation of effect of sea buckthorn seed oil [J]. *Journal of the Chinese Cereals and Oils Society*, 2023, 38(11): 134-40
- [17] Zhou Shiyang. Research on production process of refined tallow [J]. *Cereals, Oils and Food Science and Technology*, 2011, 19(05): 30-2