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Research on the Production Technology of Braised Pork Skin

Yushu Wang, Guifang Chang, Chunxia Chu, He Zhu *

School of Food Science and Engineering, Shandong Agriculture and Engineering University, Jinan, China

ABSTRACT

Pig skin is a food with high nutritional value. The common pig skin food has a single taste and monotonous style, making it difficult to arouse people's desire to eat. This article aims to conduct in-depth research on the production and processing technology of pig skin, fully utilize its nutritional value, and use modern technology to develop pig skin products with unique flavors and diverse products, and name them "Braised Pork Skin". Through sensory evaluation of pig skin samples prepared under different process conditions, single factor experiments, orthogonal experiments, response surface methodology, and electron microscopy were designed to analyze the effects of cooking time, soaking time, and the ratio of pig skin to composite additives on the internal structure and sensory evaluation of pig skin. The optimal production process for making "Braised Pork Skin" was ultimately determined to be: cooking time of 35 minutes, soaking time of 4 days, and a ratio of pig skin to additives of 40:100; Thus exploring the optimal production and processing process for pig skin has certain reference value for the future development and production of pig skin.

KEYWORDS

Pork skin; Boiling time; Addition ratio; Soaking time; Production process research

1. INTRODUCTION

China is the largest producer and consumer of pork in the world, ranking first globally in pork production. According to data from the National Bureau of Statistics of China, the country's meat production increased from 84.711 million tons in 2012 to 89.8999 million tons in 2021, representing a growth rate of 6.13% over the past decade [1]. During the pig slaughtering process, large quantities of pig skin are generated. Although pig skin resources are extremely abundant, apart from a portion used in industrial leather tanning, the majority of this resource remains underutilized, leading to significant waste of high-quality pig skin protein resources.With the rapid advancement of food processing technologies, there has been a growing understanding of pig skin, and diverse avenues for its further development and utilization have been explored, thereby enhancing its economic value [2].

Pork skin is primarily composed of water, protein, a small amount of fat, and minerals. Its composition consists of approximately 65% water, 2% fat, 0.5% minerals, and 33% protein. Pork skin is a high-protein raw material for meat products, offering high nutritional value; it can enhance skin elasticity, reduce the formation of wrinkles, and exert anti-aging and cosmetic effects. Pork skin is therefore classified as a food ingredient that is high in protein, low in fat, and possesses certain health-promoting properties [3].

However, the flavor range of pigskin products currently available on the market is relatively limited. In contrast, utilizing pigskin as a novel raw material enables the development of a diverse array of flavored pigskin products, thereby meeting consumers 'demand for varied taste options. Moreover, owing to its unique elasticity and chewiness, pigskin—when processed into "Braised pork skin" —

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can deliver a distinct textural experience compared to traditional flour-based spicy strips, appealing to consumers who seek novel taste profiles. Additionally, compared to conventional spicy strips, the use of pigskin as a raw material reduces flour consumption, thereby lowering the carbohydrate content to some extent and aligning with consumers' growing preference for healthy foods. Given the pronounced homogenization of traditional products, adopting this innovative raw material—pigskin—can facilitate product differentiation.

This study conducts further research and development on the utilization of pig skin, employing pig skin that has passed relevant regulatory inspections and is free from any diseases for processing, aiming to produce a flavored product named "Braised Pork Skin," and performing systematic research and analysis on its production process.

2. MATERIALS AND METHODS

2.1. Materials and Reagents

Pig skin, purified water, salt, sugar, sodium glutamate, disodium monosodium glutamate, yeast extract, pickled pepper brine, chili oil, soy lecithin.

2.2. Instruments and Equipment

Induction cookers, pots, knives, electronic scales, cutting boards, weighing paper, disposable paper cups, glass rods, vacuum packaging bags, vacuum packaging machines, refrigerators, and cold storage cabinets.

2.3. Experimental Methods

2.3.1. Experimental Processes

Defrost pork skin → Boil purified water, then add the pork skin → Place the pork skin in cooled purified water for cooling and rinsing → Remove residual fat → Cut into uniformly sized strips → Repeat the rinsing process until all fat is completely removed → Weigh the pork skin → Vacuum pack → Soak → Discard the soaking solution → Vacuum-seal the packaging Add various additives → Weighing → Prepare soaking solution

2.3.2. Sensory Evaluation Protocol

Sensory evaluation is a scientific method used to elicit, measure, analyze, and interpret the sensory characteristics of a product as perceived by individuals through vision, olfaction, touch, taste, and hearing [4]. A methodology that employs "humans" as the primary tool, utilizes scientific and objective approaches, leverages the senses of sight, smell, taste, touch, and hearing, and integrates knowledge from psychological, physiological, physical, chemical, and statistical disciplines to assess the sensory quality attributes of food—such as color, aroma, flavor, appearance, and texture [5, 6].

In this experiment, the Braised pork skin product was evaluated based on its color, flavor, tenderness, and overall mouthfeel. Additionally, sensory assessments were conducted on the cooking duration of the pigskin, the ratio of the soaking solution to the pigskin, and the duration of soaking. The evaluation panel consisted of ten members, comprising an equal number of males and females [7]. The sensory scoring was conducted on a 100-point scale, and the average score was calculated from the individual ratings. The evaluation criteria, standards, and corresponding scores are detailed in Table 1.

Table 1. Sensory evaluation standards for the production process of pig skin cream

Evaluation Criteria	code of points	Score/points
colour and lustre	Translucent in color with a lustrous sheen	21-25
	The color is translucent, with a slightly dull hue.	16-20
	The color is dull, with no distinct luster.	0-15
special flavour	It has a moderate saltiness and no fishy odor.	21-25
	The overall flavor is relatively bland, salty, or possesses a distinct fishy odor.	16-20
	It has a distinct fishy odor and lacks both a sweet and a salty taste.	0-15
tenderness	Excellent tenderness with moderate firmness	21-25
	Tenderness is average; firmness is average.	16-20
	Poor tenderness: either too soft or too hard	0-15
Overall mouthfeel	Delicate texture with high elasticity	21-25
	The texture is relatively fine, with moderate elasticity.	16-20
	The texture is coarse, and it lacks elasticity.	0-15

2.3.3. Single-factor Experimental Study on the Production Process of Braised Pork Skin

(1) Experimental Design of Cooking Time for Pig Skin on the Texture of the Pig Skin Flavouring Product

Pig skins from the same batch, of equal mass, were placed in separately pre-boiled pots and heated at a power of 1800 W for 15, 25, 35, 45, and 55 min, respectively [8]. The comprehensive score obtained from sensory evaluation shall serve as the basis for assessing the finished product.

(2) Experimental Design of the Ratio of Pork Skin to Soaking Solution on the Texture of Pork Skin Soaking Process

Equal amounts of pork skin were taken under identical boiling conditions, then placed in solutions with skin-to-liquid ratios of 20:100,30:100,40:100,50:100, and 60:100, respectively; the mixtures were stirred evenly and subsequently immersed continuously for 3 days at temperatures ranging from 0 °C to 2 °C [8]. The final product shall be evaluated based on its comprehensive score derived from sensory evaluation.

(3) Experimental Design on the Impact of Soaking Time on the Texture of Processed Pork Skin

Equal amounts of pre-boiled pig skin were taken with a skin-to-liquid ratio of 40:100, and each sample was immersed continuously in an environment maintained at 0 °C–2 °C for 1, 2, 3, 4, 5, and 6 days [8]; the evaluation criterion was sensory evaluation.

2.3.4. Experimental Design of the Orthogonal Experiment for the Production Process of Pigskin Soothing Agent

In the study of the production process of pork skin crispness, three key factors were selected for an orthogonal design experiment: boiling time, skin-to-liquid ratio, and soaking time. To ensure the accuracy and reliability of the experimental results, each factor was evaluated at three levels, as detailed in Table 1-2; the orthogonal experimental design and range analysis were then conducted using IBM SPSS Statistics 26.

Regarding the cooking duration, three distinct time points were selected for the experiments: 25 minutes, 35 minutes, and 45 minutes. By cooking the pork skin at these different time points, the effects of varying cooking durations on the crispness and texture of the pork skin can be observed.

For the skin-to-liquid ratio, three different ratios were selected for experimentation: 20:100,40:100, and 60:100. By adjusting the ratio of pig skin to the soaking solution, the effects of these varying ratios on the concentration and flavor profile of the pig skin extract can be investigated.

For the soaking duration, the selected time periods were 2 d, 4 d, and 6 d. By soaking pork skin for these different durations, the effects of varying soaking times on the softness and flavor profile of the pork skin can be investigated [8].

For the soaking duration, the selected time periods were 2 d, 4 d, and 6 d. By soaking pork skin for these different durations, the effects of varying soaking times on the softness and flavor profile of the pork skin can be investigated.

Following the implementation of an orthogonal design experiment, statistical analysis of the experimental results enables the determination of the extent to which different factor levels influence the production process of pig skin crisp, as well as the optimal combination of boiling duration, skin-to-liquid ratio, and soaking time [9]. These findings will provide a scientific foundation for the production of pig skin crisp, facilitating the optimization of production processes and enhancing both product quality and sensory characteristics.

Table 2. Factors and levels of pig skin soaking

Factors / Levels	A Cooking time (°C)	B skin-to-serum ratio (%)	C soak period (d)
1	25	20	2
2	35	40	4
3	45	60	6

2.3.5. Experimental Design of the Response Surface for the Production Process of Pigskin Soothing Agent

Based on the results of single-factor and orthogonal experiments, sensory evaluation scores were used as the response variable. Using Design-Expert 13, a response surface Box-Behnken experimental design was developed to investigate three single factors that significantly influence pork skin quality, employing a 3-factor, 3-level experimental design. The optimal formulation for pork skin was subsequently selected. The specific factors and their levels used in the response surface analysis are detailed in Table 2.

2.3.6. Experimental Design for the Microstructure of Braised pork skin

In the experimental study on the microscopic structure analysis of pig skin, a single pig skin sample was selected as the research subject to ensure a consistent basis for comparison. This sample was then divided into three groups: 1) raw pig skin without any treatment; 2) pig skin subjected solely to boiling treatment; and 3) pig skin that underwent the complete processing sequence.

Each batch of pig skin was cut into uniform cubic samples, each measuring 5 mm in length and width, and 2 mm in thickness. Subsequently, opposite faces of each test surface were clearly marked to facilitate accurate differentiation and positioning during subsequent observations.

Treat the test surface with anhydrous ethanol. Subsequently, place the sample in a dryer preheated to a constant temperature for drying. During the drying process, it is essential to ensure uniform temperature distribution and stability to achieve consistent drying results.

After drying, place the samples at room temperature to cool. Once the temperature has stabilized at room temperature, transfer the samples to clean culture dishes and seal the dishes. Then, transfer the samples to a ultra-low temperature freezer (-80 °C) for freezing.

After freezing for 24 hours, transfer the sample to a freeze dryer for lyophilization.

Upon completion of all preprocessing steps, high-resolution electron microscopy at 500× magnification was employed to conduct detailed observations of the microstructure of pig skin samples from each treatment group. This enabled the observation of collagen fiber arrangement, pore structure, and other microstructural features of the pig skin under different treatment conditions, facilitating in-depth comparative analysis [10].

3. RESULTS AND ANALYSIS

3.1. Results of Single-Factor Experimental Analysis for the Production Process of Pork Skin Shuang

3.1.1. Effects of Boiling Duration on the Texture of Processed Pig Skin

As shown in Figure 3, the scoring increases as the boiling duration approaches 35 min; the scoring varies significantly between 15 min and 35 min, while the difference in scoring is minimal between 35 min and 55 min. Therefore, based on a comprehensive evaluation, the optimal boiling duration for pork skin is 35 min.

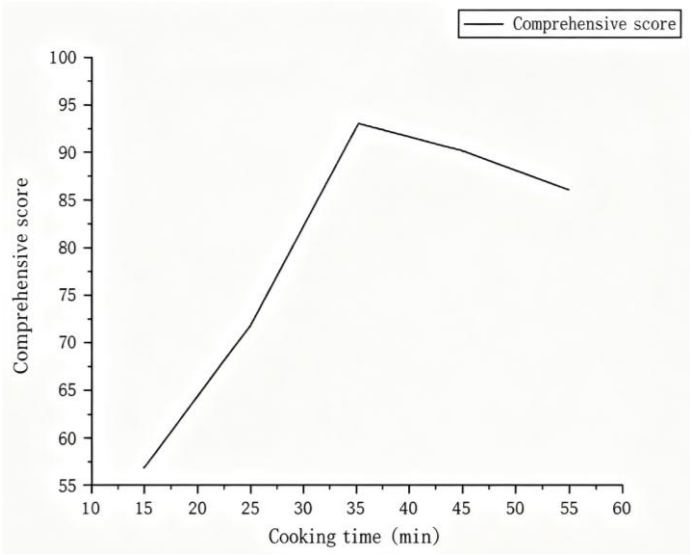


Figure 1. Effect of different cooking time on tast

3.1.2. Effect of the Ratio of Pork Skin To Soaking Solution on the Texture of the Pork Skin Pickling Process Product

As shown in Figure 2, the sensory evaluation results indicate that the ratio of pig skin to soaking solution reaches its maximum value at 40:100, although the differences compared to the ratios of 20:100 and 30:100 are not significant [8]. Most sensory evaluators believe that an excessive proportion of pork skin can lead to uneven flavor distribution, whereas an insufficient proportion of pork skin may result in excessive flavor absorption, adversely affecting texture and overall flavor profile. Therefore, determining the appropriate ratio of pork skin to brine is a critical step in the process.

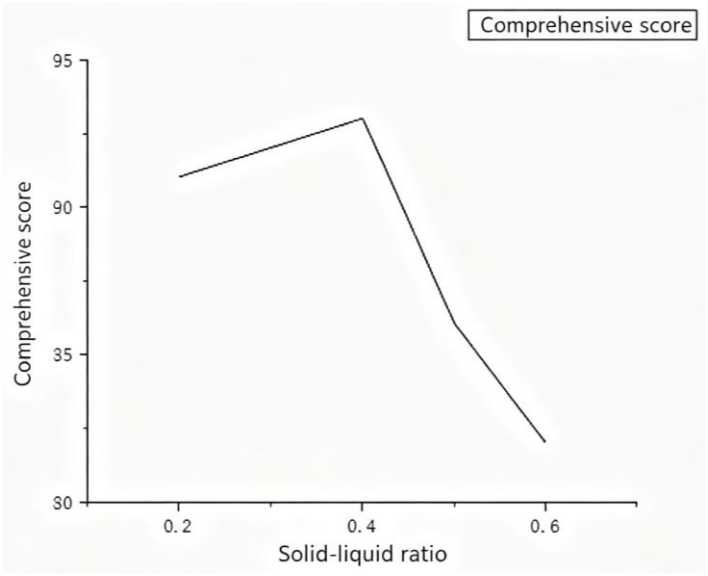


Figure 2. Effect of different skin liquid ratio on taste

3.1.3. Effect of Soaking Time on the Texture of the Pork Skin Shuang Production Process

As shown in Figure 3, as the soaking duration increases, the overall sensory evaluation score of pig skin initially rises and then declines. Between 3 and 5 days of soaking and fermentation, the pig skin reaches its optimal state of flavor absorption, with both the flavor and texture evaluation panels rating it as excellent. During the 1–2 day period, the evaluation panels deemed the soaking duration too short, resulting in a relatively hard texture and insufficient flavor absorption; however, by day 6, the pig skin exhibits a softer texture and a more pronounced salty flavor. Consequently, a soaking duration of 4 days was selected as the optimal condition.

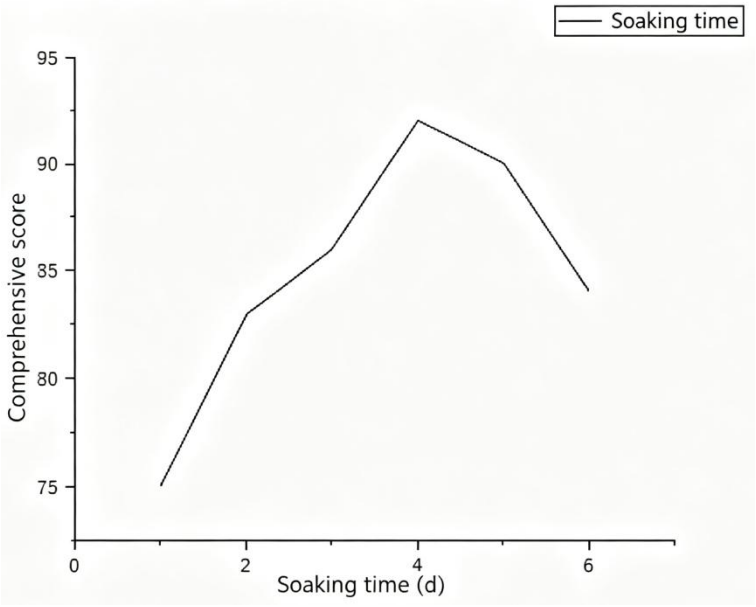


Figure 3. Results of the influence of soaking time on taste

3.2. Results of the orthogonal experimental design for the production process of Braised pork skin

The results of the orthogonal experiment were compiled, and range analysis was performed using IBM SPSS Statistics 26; by integrating the single-factor experimental results with the mean values of each factor level, the final analysis results are presented in Table 3.

Table 3. Range analysis of orthogonal experimental results for the production process of pig skin cream

test number	Cooking time (℃)	B skin-to-serum ratio (%)		Csoak period (d)	Overall Score
1	35	20		4	98.86
2	45	40		2	95.21
3	45	20		6	95.90
4	25	60		6	84.50
5	45	60		4	88.21
6	25	20		2	86.11
7	25	40		4	92.08
8	35	60		2	90.66
9	35	40		6	97.84
Kprice	1	262.69	281.87	271.98	
	2	384.26	285.13	280.15	
	3	183.42	263.37	278.24	
Kavgprice	1	87.56	93.96	90.66	
	2	96.06	95.04	93.38	
	3	91.71	87.79	92.75	
Optimal level		35	40	4	
R		8.5	7.25	2.72	
Horizontal quantity		3	3	3	
Number of repetitions per level, r		3	3	3	

Based on a comprehensive analysis of various factors and indicators, the following conclusions can be drawn using the R-value: among the factors influencing the sensory score of the pig skin crisp product, the relative importance of the skin-to-liquid ratio, soaking time, and boiling time follows the order: boiling time> skin-to-liquid ratio> soaking time. By examining the average experimental data for each factor at its respective levels in Figure 4, the optimal experimental protocol for this product was determined to be $A_2B_2C_2$, namely: boiling time of 35 minutes, skin-to-liquid ratio of 40:100, and soaking time of 4 days [11].

Using this optimized experimental protocol, the prepared "Pig Skin Refresh" product demonstrated outstanding performance in terms of color, flavor, tenderness, and overall mouthfeel. Overall, the product exhibits a translucent white hue, a soft and smooth texture, a rich flavor profile, and moderate chewiness with distinct layered sensations [12, 13].

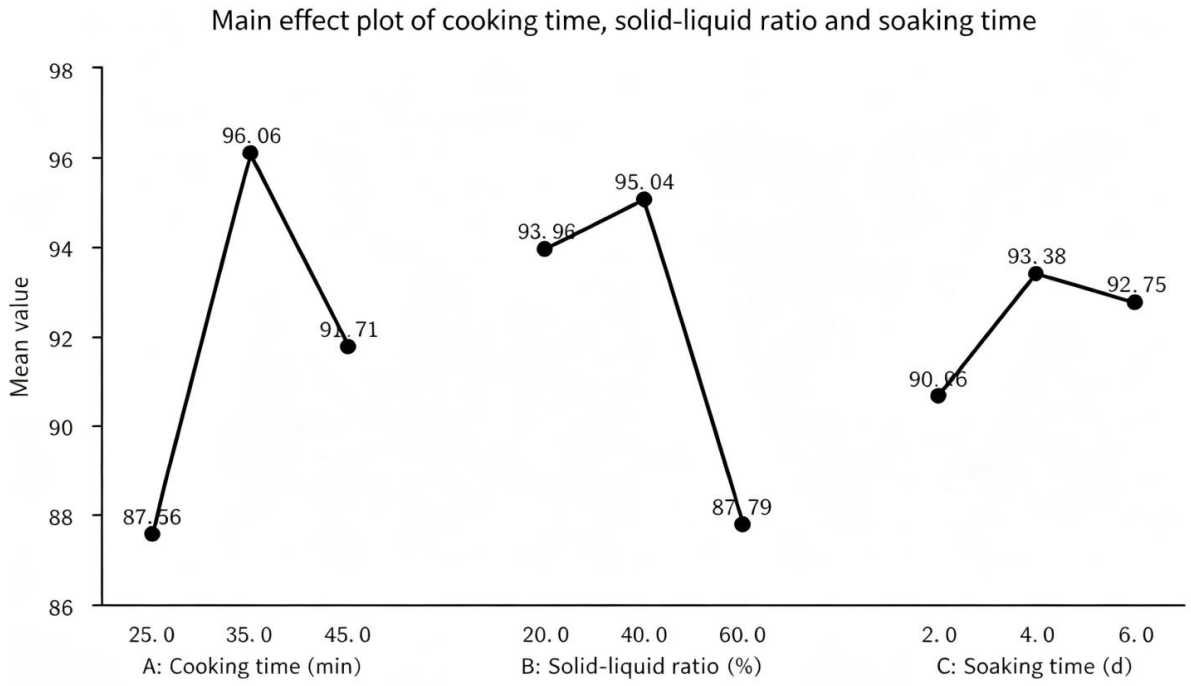


Figure 4. Mean values of cooking time, skin to liquid ratio, and soaking time at various levels

3.3. Analysis of Experimental Results for the Pigskin Sensitivity Surface

3.3.1. Response to Interview Design and Results

Based on the results of single-factor sensory evaluations, a Box-Behnken design central composite experimental model was established, a quadratic equation was fitted, and the optimal formulation of ingredients for producing Braised Pork Skin, along with the highest theoretical sensory score, was determined [14]. A three-factor, three-level response surface experimental study was then conducted using the three single factors of Braised Pork Skin; the experimental results are presented in Table

Table 4. Response Surface Test Design and Results

Experiment No.	Acooking time (℃)	B soak period (d)	Cskin-to-serum ratio (%)	Overall Score
1	35	4	40	96.81
2	35	2	20	81.7
3	45	2	40	82.86
4	45	6	40	88.21
5	35	2	60	82.39
6	35	4	40	98.9
7	35	4	40	96.4
8	25	2	40	92.1
9	25	4	60	87.51
10	35	6	20	81.23
11	35	6	60	86.81
12	35	4	40	98.6
13	25	6	40	87.97
14	25	4	20	88.21
15	45	4	60	86.9
16	35	4	40	97.04
17	45	4	20	81.32

3.3.2. Model Construction and Significance Testing of the Response Surface

During the multiple regression analysis of the data presented in Table 4 using the data analysis software Design-Expert 13, a quadratic equation model was constructed; this model elucidates the mathematical relationship between sensory scores and three independent variables (cooking time A, skin-to-saft ratio B, and soaking time C).

The model can be expressed as: $R = 33.4 + 1.39A + 7.67B + 1.30C + 0.118AB + 0.00785BC + 0.031BC - 0.0341A^2 - 1.60B^2 - 0.0204C^2$

Here, R denotes the sensory score, while A, B, and C represent cooking time, skin-to-saft ratio, and soaking time, respectively. The interaction terms AB and BC, along with the quadratic terms A^2, B^2, and C^2 in the model, account for both the interactions between factors and their nonlinear effects.

According to the regression model coefficients and their significance test results presented in Table 5, the p-value of this regression model is less than 0.01, indicating that the model possesses extremely high statistical significance. Furthermore, the p-value of the model's lack-of-fit test is 0.7714, which exceeds the conventional significance level of 0.05; this demonstrates that the model exhibits appropriate goodness-of-fit and shows no significant lack-of-fit.

The coefficient of determination (R^2) of the model is 0.9900, which exceeds 0.8000, further confirming the statistical significance and goodness of fit of the model.The adjusted coefficient of determination, Adj-R^2, is 0.9770, indicating that 97.0% of the data can be explained by this model [15].

The effect of cooking time and skin-to-saft ratio on sensory scores was highly significant ($p<0.01$), whereas the effect of soaking time on sensory evaluation was not significant ($p>0.05$). Based on the significance analysis of regression coefficients [16], the relative importance of the three single factors on sensory scores was ranked as follows: cooking time> skin-to-saft ratio> soaking time, which is consistent with the results of the orthogonal experimental design.

Table 5. Regression Model ANOVA Table

Source of variance	quadratic sum	Degrees of freedom	Mean square	F price	P price	conspicuousness
model	641.21	9	71.25	76.61	< 0.0001	**
A-Cooking time	34.03	1	34.03	36.60	0.0005	**
B-soak period	3.34	1	3.34	3.59	0.0999	ns
C–serum/lymph ratio	15.54	1	15.54	16.71	0.0046	**
AB	22.47	1	22.47	24.16	0.0017	**
AC	9.86	1	9.86	10.60	0.0139	*
BC	5.98	1	5.98	6.43	0.0389	*
A^2	48.85	1	48.85	52.53	0.0002	**
B^2	170.25	1	170.25	183.07	< 0.0001	**
C^2	280.27	1	280.27	301.39	< 0.0001	**
residual	6.51	7	0.9299			
Acamorphia	1.45	3	0.4848	0.3836	0.7714	ns
pure error	5.06	4	1.26			
sum	647.72	16				
R^2=0.9900 Adjusted R^2=0.9770						

Note: * indicates $p < 0.05$, a statistically significant difference; ** indicates $p < 0.01$, a highly statistically significant difference; ns indicates $p > 0.05$, a non-significant difference.

3.3.3. Response Surface Curve Analysis

Response Surface Methodology (RSM) is a statistical technique used to optimize multi-variable experiments. In RSM, contour plots and 3D plots are commonly employed tools to visually illustrate the interactions among factors and their effects on the outcomes.

Contour maps are formed by connecting points that share the same response value, thereby illustrating the equality of response values under different combinations of factors. The spacing of the contour lines can indicate the significance of a two-factor interaction; if the contour lines form an elliptical shape, it suggests a significant interaction between the two factors, whereas if they form a circular shape, it indicates that the interaction is not significant [17].

The 3D plot illustrates the magnitude of the two-factor interaction effect on sensory scores by depicting the tilt and slope of surfaces within three-dimensional space. The steeper the tilt and slope, the more pronounced the effect of that factor is [18].

As shown in Figures 2-8, 2-9, and 2-10, the response surfaces exhibit relatively steep gradients, indicating that the three individual factors—cooking time, soaking time, and skin-to-liquid ratio—have a significant effect on the sensory scores.The contour lines in Figures 2-8 and 2-9 exhibit an elliptical shape, indicating that there is a significant interaction between the cooking time and the soaking time, as well as between the cooking time and the skin-to-saft ratio [15].

Therefore, it can be concluded that the three factors—cooking time, soaking time, and skin-to-saft ratio—not only exert a significant individual effect on the sensory scores, but also exhibit significant interactive effects among themselves.

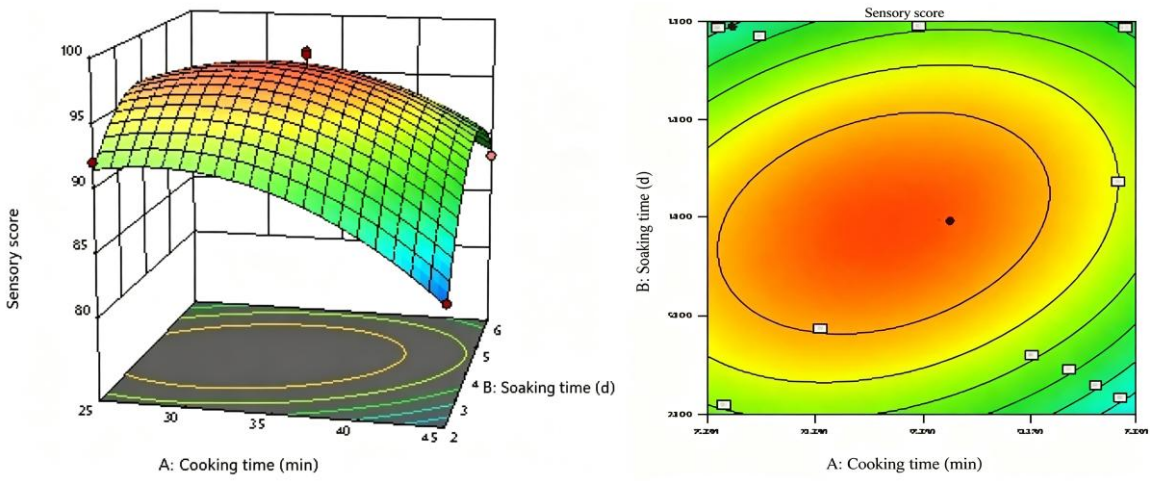


Figure 5. The interaction between cooking time and soaking time on the sensory evaluation score of pig skin freshness

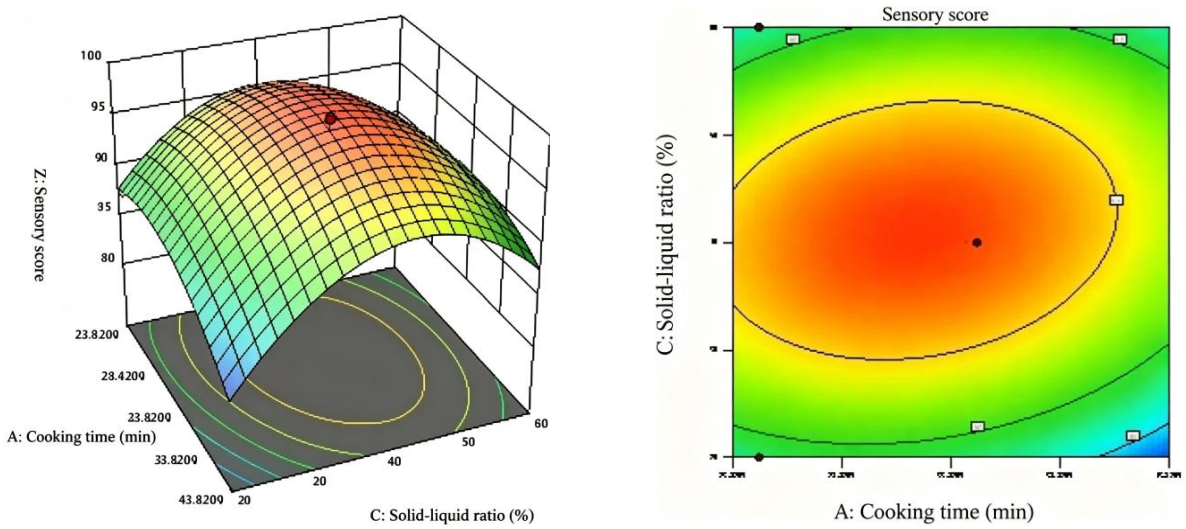


Figure 6. The interaction between cooking time and skin to liquid ratio on the sensory evaluation score of pig skin freshness

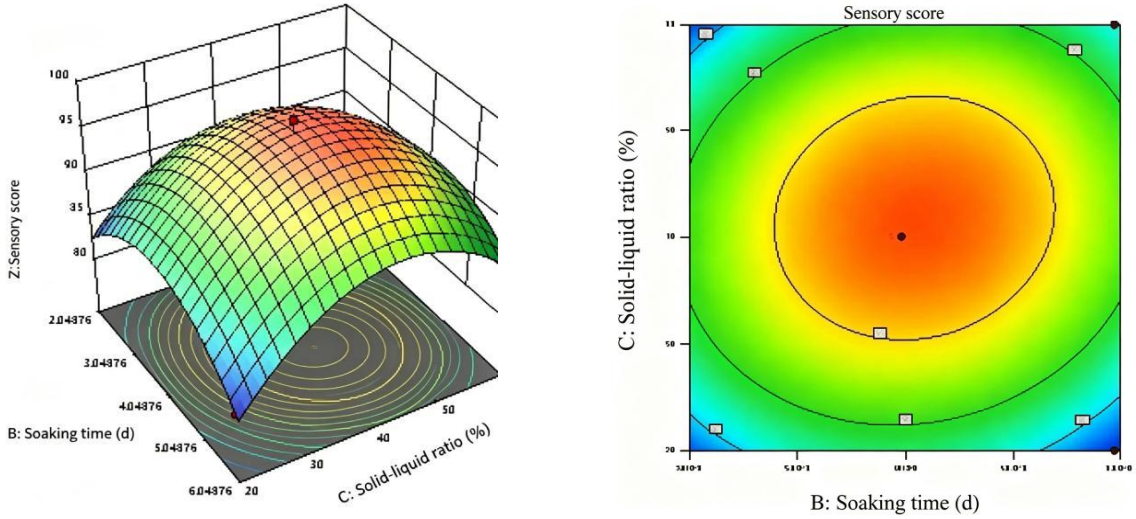


Figure 7. The interaction between soaking time and skin to liquid ratio on the sensory evaluation score of pig skin freshness

3.3.4. Determination of Optimal Conditions and Validation of the Regression Model

The response surface methodology was employed to optimize the processing conditions for Braised Pork Skin, yielding a regression model. The experimental formulation was then appropriately adjusted; the optimized formulation parameters were subsequently applied to validation trials of Braised Pork Skin, followed by sensory evaluation. The results are presented in Table 6.

Table 6. Determination of optimal conditions and validation of regression models

project	target	Low level	High level	optimal choice	experimental verification
Cooking time (min)	In range	25	45	32.1095	35
soak period(d)	in range	2	6	4.00555	4
Skin-to-lymph ratio (%)	in range	20	60	41.1626	40
Sensory score	maximize	81.23	98.9	97.8887	97.61

Using the response surface methodology, the optimal processing conditions for producing pork skin crispness were determined as follows: boiling time of 32.1095 min, soaking time of 4.00555 d, and skin-to-liquid ratio of 41.1626%. In light of practical operational considerations, these parameters were adjusted to a boiling time of 35 min, a soaking time of 4 d, and a skin-to-liquid ratio of 40%. Three parallel trials were then conducted under these optimized conditions, yielding a sensory score of 97.61, which closely aligns with the theoretical value. This confirms that the modified formulation still achieves the desired product quality.

3.4. Microstructural Analysis of Braised Pork Skin under Electron Microscopy

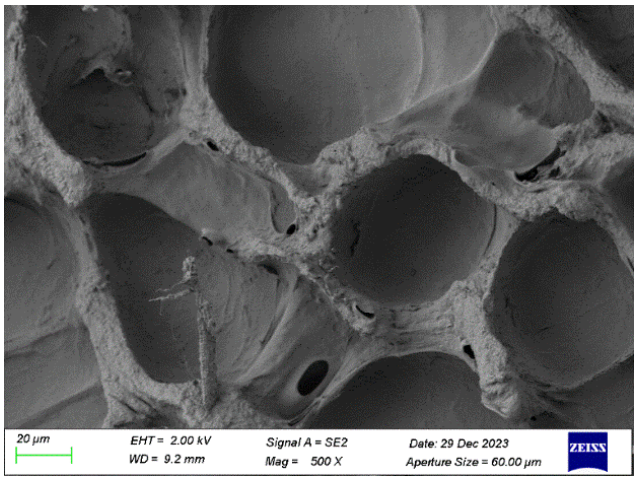


Figure 8. Microscopic structure of pig skin

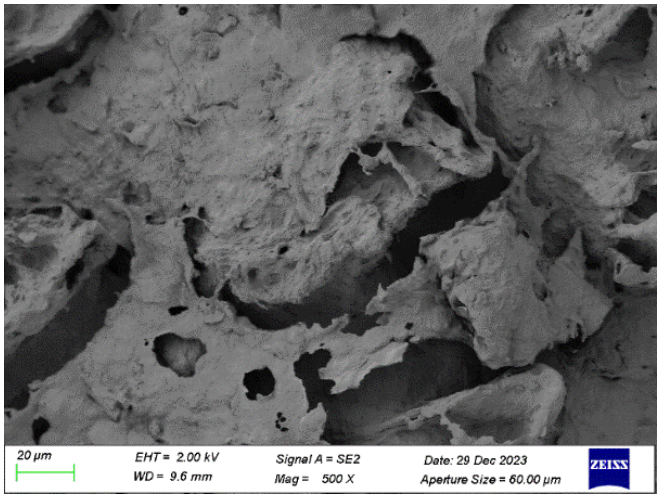


Figure 9. Microscopic structure of cooked pig skin

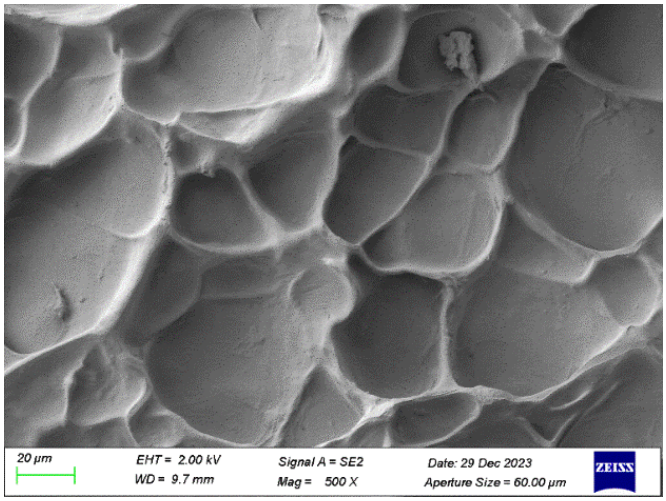


Figure 10. pig skin treated by complete process flow

The effects of various treatment conditions on porcine skin under scanning electron microscopy can be concluded by examining Figures 2-8, 2-9, and 2-10. These figures display the microstructures of raw porcine skin, cooked porcine skin, and porcine skin that has undergone the complete processing sequence under scanning electron microscopy [19].

First, it can be observed that the structure of raw pork skin is relatively coarse, with numerous voids and cracks on its surface. This may be attributed to the fact that the raw pork skin has undergone no treatment, thereby retaining its original microstructural characteristics. In contrast, cooked pork skin and pork skin that has undergone the complete processing sequence exhibit a more uniform and smoother structure, along with fewer voids [10]. This indicates that treated pork skin has undergone certain microstructural changes.

In particular, pig skin that has undergone the complete processing sequence exhibits the smallest intercellular spaces and the most dense structure. This finding demonstrates that the complete processing sequence has a positive effect on the microstructure of pig skin. Following treatment with the soaking solution, the intercellular spaces on the surface of the pig skin are effectively sealed, thereby retaining more moisture. This enhanced water retention capacity is of significant importance for the texture and mouthfeel of the pig skin.

Furthermore, pig skin that has undergone the complete processing sequence may exhibit improved elasticity and toughness. This is because, during the processing stage, the collagen and other proteins in the pig skin undergo certain modifications, rendering it more suitable for consumption.

Observation of the microstructure of pork skin under various processing conditions using scanning electron microscopy reveals that pork skin undergoing the complete processing sequence exhibits a more uniform and smoother structure, retains greater moisture content, and demonstrates improved water retention capacity. These characteristics exert positive effects on the texture, mouthfeel, and cooking performance of the pork skin [20].

4. CONCLUSION

Using single-factor experiments, orthogonal experiments, and response surface methodology, this study determined the effects of cooking time, the ratio of pork skin to additives, and marination time on the sensory characteristics of the product. Additionally, scanning electron microscopy was employed to examine changes in the internal microstructure of the treated pork skin, ultimately yielding the optimal processing parameters for producing "Pork Skin Shuang." The experimental conditions were as follows: boiling time of 35 min, skin-to-liquid ratio of 40%, and soaking time of 4 days.

In this study, we analyzed the processing workflow of pork skin and employed sensory evaluation methods to investigate its production techniques, ultimately developing a product named "Pork Skin Shuang" characterized by favorable flavor and superior quality. However, the following issues remain and warrant further investigation:

(1) Although sensory analysis methods can, to some extent, reflect the quality of pork skin, they carry a degree of subjectivity; therefore, it may be advisable to incorporate additional analytical methods—such as, in addition to sensory evaluation and scanning electron microscopy, the following analytical techniques—to assess the quality of pork skin:

1) Instrumental analysis: Using specialized testing equipment to accurately measure the thickness, elasticity, and moisture content of pig skin, thereby assessing the quality of the pig skin.

2) Nutritional Composition Analysis: By analyzing the contents of proteins, fats, collagen, and other components in pork skin, this study aims to evaluate the nutritional value of pork skin.

3) Spectroscopic analysis: Utilize techniques such as infrared spectroscopy and Raman spectroscopy to analyze the composition and structure of pig skin, thereby assessing its quality and performance characteristics.

(2) Given that pigskin raw materials from different sources may vary, subsequent experiments could expand the range of sample sources and compare their process parameters to validate the universality of the process.

Through the aforementioned improvements and further in-depth experimentation, the production and processing techniques for pig skin can be comprehensively and accurately refined, thereby providing more reliable scientific foundations for actual production, which in turn will facilitate the enhancement of high-quality pig skin products and the standardized development of the industry.

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