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EFFECTS OF ADDING DIFFERENT CONTENTS OF PIG RIND ON PHYSICAL AND CHEMICAL PROPERTIES AND SENSORY QUALITIES OF WHEAT BRAN CHICKEN SAUSAGE

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Chicken sausage is one of the very popular meat products. In order to change the nutritional composition of chicken sausage and increase the content of dietary fiber, we add bran, but it affects the textural properties of chicken sausage. Pork rind is rich in collagen and is a natural and safe food gel. Pork rind content affects the cooking loss, color, TPA, moisture distribution and sensory evaluation results of cooked sausage products. In this study, six different pigskin content treatment experiments were set up: 0 %, 5 %, 10 %, 15 %, 20 %, and 25 %.

This research shows that adding pork rind can reduce cooking loss during the sausage heating process. As more pork rind was added, the L and b* values of minced meat and chicken sausage gradually increased, while the a* value gradually decreased. The chewiness of the sausages in the test group was significantly reduced ($p<0.05$), except for T1, while the elasticity, recovery, and cohesiveness did not change significantly ($p>0.05$), and the hardness value increased significantly ($p<0.05$). The hardness of the sausages increased significantly (except in T5). Compared with the control group, the relaxation times of hydrated water and immobilized water in the treatment group became shorter, while the relaxation times of free water shifted to a longer direction. Sensory evaluation revealed that the hardness score of the T5 group was significantly lower than that of the control group. Based on these results, the sausage quality of the T3 group (pork rind 15 %) was the highest.*

This study improves the gel properties of bran chicken sausage, provides scientific data support for the application of pork rind in chicken sausage, improving the application value of pork rind

Keywords: pig skin, quality improvement, physico-chemical property, gel properties, sensory evaluation

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1. Introduction

The fat content of sausage is usually about 20~30 %, and it is widely welcomed by consumers for its rich nutrition and unique taste. Excessive intake of fat not only causes obesity symptoms, but is also accompanied by the possibility of various cardiovascular and cerebrovascular diseases and diabetes [1]. Therefore, the meat industry needs to find a fat substitute and develop low-fat and healthy meat products with good eating quality.

In recent years, the application research of plant materials in sausages has attracted the attention of meat scientists around the world, especially the most relevant research on dietary fiber. Dietary fiber is a nonstarch polysaccharide having resistance to absorption and digestion by the enzymes present in the human gastrointestinal tract [2]. Dietary fiber has been demonstrated to reduce postprandial blood glucose level, insulin, glucose, and triglyceride concentration [3], while also lowering blood cholesterol levels. In the field of meat science, on the one hand, it can give full play to the functional properties of dietary fiber, such as strong water absorption and water-holding capacity; on the other hand, it can improve the sensory quality of meat products, such as color, texture and taste, which can satisfy different needs of consumer groups [4]. The inclusion of banana peel powder raises the nutritional value with regard to an increase in dietary fiber and a reduction in the sausage fat content. However, with banana peel powder incorporation, a hard texture and darkening of the sausage were observed [2].

Dietary fiber has been shown to be used in the meat industry as a fat substitute. A small amount of dietary fiber can improve the eating quality of meat products to a certain extent, but excessively increasing dietary fiber will lead to a significant decrease in the acceptability of meat products [5]. Therefore, reasonable control of the amount of dietary fiber is a problem that needs to be solved in the field of new meat product development.

Pork animal products occupy a dominant position. Pork production produces a lot of by-products, including pork rinds. Generally, pig skin accounts for about 10 % of the carcass quality, except for some used in food gelatin, processing leather, etc., the comprehensive utilization rate and utilization value are low. In addition, pigskin extracts are rich in collagen, which is a protein with covalently linked three-stranded peptide chains, with a compact structure and poor hydrophilicity [6]. During the heating process, the denatured collagen molecules are regularly arranged to form a three-dimensional network structure, which has good gel properties and can significantly improve the water retention of sausages [7]. Therefore, in this study, pig skin was heated and pre-cooked to improve the water retention and gel properties of pig skin collagen.

Chicken has high protein, low fat, and high vitamin B content, which can play a role in anti-fatigue and skin protection [8, 9]. The protein content of chicken breast is approximately 20 %, the fat content is only 3 %, and it is easily absorbed and utilized by the human body. Gel properties are an important factor in measuring the quality of minced chicken products. Owing to the specialty of the protein fibers in chicken, chicken minced products have poor elasticity and a single flavor. Adding wheat bran to chicken sausages reduces their hardness and toughness. Compared with duck meat, chicken minced meat has a higher protein content, and the higher protein content is more favorable for the dissolution of myofibrillar proteins, which can make the protein between the meat minced form a better network gel structure.

Wheat bran is an important by-product of flour making. It is a mixture of wheat bran with part of endosperm and wheat embryo. Wheat bran is rich in protein, fat, dietary fiber, vitamins, minerals, oligosaccharides, enzymes and phenolic compounds. Compared with flour, the protein content of wheat bran is 1.6 times that of wheat flour, and the distribution of protein components is more uniform, the nutritional value is higher, and the mineral content is more than 20 times that of flour [10].

In order to prevent the addition of dietary fiber from reducing the gel properties of sausages, it is necessary to add starch, food glue, etc. to sausages to improve the texture properties of sausages. Factory-extracted animal gelatin is often used in the meat processing industry, but there are relatively few applications and research on the direct addition of fresh pig skins to sausages.

Therefore, research on different amounts of pig rind improving the gel properties of sausage is relevant. At the same time, the comprehensive utilization rate of pig skins and the factory efficiency are improved.

2. Literature review and problem statement

The paper showed that pork rind was an important by-product of pork processing. The protein content of pork rind is approximately 33 %, of which collagen accounts for 87.8 % of the total protein [11]. Furthermore, pork rind exhibits good gel properties [12], adding it to meat products such as Western-style sausages and ham sausages can improve their water-holding capacity and tenderness, and improve the properties of sausage slices [11]. Pork rind is increasingly used in sausages as collagen with excellent properties. The previous study showed that the rheological and textural properties of Harbin Red sausage with pork rind collagen powder were improved, the sausage hardness, elasticity, stickiness, and chewiness values were increased, cooking losses were reduced, and scanning electron microscopy images showed increased compactness and uniformity [13]. Scientists reported that they studied the effect of a mixture of pork rind and coconut flour on the gel and rheological properties of squid myofibrillar proteins [14]. The researchers improved the traditional blood sausage based on pork rind quality characteristics [15]. It has been reported that the addition of pork rind to bagged sausages from Hannover, Germany is as high as 36 %. Owing to the bristles and toughness on the surface of pork rind and the complex processing technology [16], people in many countries worldwide do not consume it. In China, pork rind is often used to extract collagen and make pork rind gels, fry, and dried pork rind. The utilization and added value of pork rind are not high [16]. It is used as an industrial raw material to make collagen. However, there are very few studies on adding fresh pork rind directly to sausages to improve sausage quality. All this allows us to argue that it is appropriate to conduct a study devoted to improving the gelatinability of bran chicken sausage.

Wheat bran is an important by-product of wheat flour milling. Data from Chinese laboratories have shown that wheat bran is rich in dietary fiber (31.4 %) and protein (18 %), with a fat content of only 0.6 %. In order to improve the nutritional composition and quality characteristics of food, bran is often added in food development and manufacturing. The researchers used a mixture of pork skin and wheat fiber as a fat substitute in frankfurters to obtain lower calories, higher moisture, protein content, and emulsion stability [17]. The inclusion of sorghum bran into beef sausage improves the discoloration, oxidation, and pH value of the sausage and significantly improves the texture value of the sausage, including firmness, cohesion, elasticity, gumminess, and chewiness [18]. The scholars added 6 % wheat bran dietary fiber to pork (at a 1:9 ratio of fat to lean) to make sausages with good taste, excellent color, and other indicators, and improved sensory and nutritional properties. The scientists added rye bran to meatballs, which improved their graininess, mouthfeel, and flavor [19]. Scientists reported that they studied the effects of rye bran, oat bran, and barley fiber on grain additives in low-fat sausages and meatballs, and found that oat bran had good thermal gelation ability and rye bran in meatballs [20]. The results of previous studies fully demonstrate that adding wheat bran can improve the nutritional composition and quality characteristics of sausage products. All this suggests that it is advisable to conduct a study on the effect of adding bran in chicken sausages.

In conclusion, it has become a trend to add plant raw materials to sausages to improve the nutritional composition of sausages, but it will bring about changes in texture and taste. As collagen, pork rind can improve the texture and quality of sausages. Analysis and determination of sausage cooking loss, texture characteristics, sensory changes and other indicators can provide a theoretical basis for further applications.

3. The aim and objectives of the study

The aim of this work was to study the effect of pig rind addition on the quality characteristics of bran chicken sausages. This may improve the quality characteristics of the sausage. This may make pig rind a natural quality improver for nutritious sausages and improve the comprehensive utilization of pig skin.

The following objectives have been set to achieve the aim:

– to determine the cooking loss, emulsion stability, and color changes of sausages with different pork rind contents;

– to determine the texture properties of sausages with different pork rind contents;

– to determine the distribution of water of sausages with different pork rind contents;

– to determine the change in sensory scores of sausages with different pork rind contents and to obtain the optimal amount of bran added in bran chicken sausages.

4. Materials and methods

In this study, pork rind, chicken and bran were used to make sausage. By changing the amount of pork rind, the cooking loss, texture change and sensory characteristics of sausage were analyzed, and the optimal amount of pig skin in bran chicken sausage was obtained. In the process of chicken emulsified sausage production, pig skin was added to improve the quality and nutritional characteristics of bran chicken sausage, which met the health requirements and improved the comprehensive utilization value of by-products, and provided a certain theoretical basis for production and application.

The pork rind was washed, the fat was removed, boiled (100 °C, 40 min), and put into a meat grinder to be broken. Wheat bran was purchased from Henan Jinyuan Grain and Oil Company (Zhengzhou, China); it was pulverized using a mill and sieved using an 80-mesh sieve, which contained 18 % protein, 0.6 % fat, and 31.4 % dietary fiber. Lean and fat pork were pre-cooled and processed using a meat grinder (mince plate diameter, 8 mm). Chinese white wine was used (Sanhua Rice Wine; Guilin Sanhua Co., Guilin, China). Spices were also used (Wang Shou Yi Shi San Xiang Co.; Zhumadian, China). The phosphate complex (sodium pyrophosphate 60 %, sodium tripolyphosphate 39 %, and sodium hexametaphosphate 1 %) was obtained from Harsen Foods Hongkong Co., Ltd. (Shantou, China). Six treatments were established in this study. The amount of pork rind added was 0 %, 5 %, 10 %, 15 %, 20 %, and 25 % of the total chicken breast meat (T1–T5, respectively). Each treatment used 400 g of chicken breast meat, and the amounts of pork rind added were 0, 20, 40, 60, 80, and 100 g (detailed formula in Table 1).

Table 1

Recipes of bran chicken sausages with different pork rind content

Raw material	Control treatment	Treatment				
		T1 (5 %)	T2 (10 %)	T3 (15 %)	T4 (20 %)	T5 (25 %)
Pork rind (g)	0.0	(20.0)	(40.0)	(60.0)	(80.0)	(100.0)
Wheat bran (g)	6.0	6.0	6.0	6.0	6.0	6.0
Chicken breast (g)	400.0	400.0	400.0	400.0	400.0	400.0
Pig back fat (g)	50.0	50.0	50.0	50.0	50.0	50.0

Note: Other ingredients include 35 g of cassave starch, 20 g of cassave modified starch, 20 g of potato starch, 7 g of salt, 1.5 g of complex phosphate, 4.5 g of complex spices, 0.5 g of pepper, 1.5 g of red yeast rice, and 2 g of red beet and ice water

Analysis of Sausage Cooking Loss and Emulsification Ability. Cooking loss was measured according to the method with the following modifications [21]. Approximately 35 g (exact weight recorded) of the raw sausage batter was placed in a 50 mL centrifuge tube and centrifuged at 3,000 r/min for 5 min to remove bubbles from the tube. The raw meat batters were stuffed into a casing (initial weight), and after heating at 75 °C for 30 min, the cooked meat batter samples were cooled to room temperature at 21 °C for 3 h. After cooling, the liquid was poured from the centrifuge tube into a glass plate (9 cm), the cooked meat batters were reweighed, and the cooking loss was calculated. The meat batters were analyzed for emulsion stability using the cooking loss method, and the liquid lost from cooking (centrifuge tube inverted for 30 min) was poured into the glass plate. The water loss is the weight reduced by the cooking lost liquid after being heated at 105 °C for 16 h, while the fat loss is the remaining sample weight after the cooking liquid is dried.

$$\text{Cooking Loss (\%)}=[W_0\,(g)-W_1\,(g)/W_0\,(g)]\times 100, \quad (1)$$

$$\text{Moisture Loss (\%)}=(W_2-W_3)/W_0\times 100, \quad (2)$$

$$\text{Fat Loss (\%)}=W_3/W_0\times 100, \quad (3)$$

where W_0 – weight of raw meat batters, W_1 – weight of cooked meat batters, W_2 – weight of cooking liquid, W_3 – remaining weight after heating.

The raw meat batter and sausage stored at 4 °C were maintained at room temperature for 1 h. The color of uncooked meat batter and cooked sausage was determined using a colorimeter (color difference meter CR-400, Shoufeng Instrument Technology Co., Ltd, Changzhou, China; calibrated with a white plate, $L^*=+97.83$, $a^*=-0.43$, $b^*=+1.98$) [22]. Sample coordinates were determined and recorded as indicators of lightness (L), redness (a), and yellowness (b).

The samples were cut into cylinders, 2 cm high×2 cm wide. Texture profile analysis was performed at room temperature using a texture analyzer (TA. XT PLUS, Stable Micro System, UK). The test conditions were as follows: the P/50 probe (50 mm Ø) was chosen for sample analysis; the rate before the test was 5 mm/s; the test rate was 1 mm/s; the strain ratio was 75 %; and the trigger force was 5 g. The parameters measured included hardness, springiness, cohesiveness, gumminess, chewiness, and resilience.

Low-field nuclear magnetic resonance (LF-NMR) technology is an emerging analysis and detection technology with many advantages such as rapidity, accuracy, and non-destructiveness. It has been widely researched and applied in many fields such as energy. LF-NMR was used to determine the dynamic distribution of water in the sausage. The sample was placed in an NMR tube (1.0 cm in diameter and 20 cm in height) with a magnetic field intensity of 0.47 T and a proton resonance frequency of 20 MHz using low-field NMR (NIU MAGs; Shang Hai, China). The Carr-Purcell-Meiboom-Gill (CPMG) pulse sequence procedure was used to determine the sample relaxation time (T2). For each sample, the program automatically scanned 100 scans, and the interval of each scan repetition was 1 s. The corresponding relaxation times (T2b, T21, and T22) and amplitudes (A2b, A21, and A22) were reflected by the inversion of T2 with the Contin software [23].

Using magnetic resonance imaging (MRI) technology, it is possible to obtain information on the water distribution inside a sample and visualize the water flow [24]. Proton density-weighted imaging (PDWI) was used in this study. PDWI mainly reflects the difference in proton density relaxation between the tissues. The tissue proton density in the images is not significantly different, and the contrast is not strong, but it has a high signal-to-noise ratio, which can be used to observe small tissue structures. The T2 relaxation spectrum and proton density-weighted image were used to obtain the hydrogen proton density and distribution inside the sample to reflect the water content and water flow information of the sample. The samples were scanned by MRI using low-field nuclear magnetic resonance technology and the system's own imaging software, and the MRI was color-processed using pseudo-color IPT.2014 software. Through the pseudo-color processing of MRI images, the distribution of water molecules in sausages can be presented more clearly.

Ten postgraduates with sensory evaluation experience, including five males and five females, were invited to form an evaluation group. The panelists were trained twice before the experiment started. The evaluation test adopted a double-blind method to evaluate sausage sensory preference, and the samples were randomly numbered and selected. The group mainly evaluated the color, smell, tissue state, taste, and overall acceptability of meat batter after cooking. The highest score for each index was 9 points and the lowest score was 1 point (1=extremely disagreeable, 9=extremely ideal), according to which the quality of the sample was judged [25]. The study protocol was approved by the ethics review board of Hezhou University. We have obtained written informed consent from all study participants. All of the procedures were performed in accordance with the Declaration of Helsinki and relevant policies in China.

The test data were analyzed using a data-processing system (DPS V8.5.lnk, China), and the test results are expressed as the standard error. Duncan's multiple range test (p<0.05) was used to determine the differences between the treatment means.

5. Results of studying the effect of pork rind content on the quality of bran chicken sausage

5. 1. Research results on sausage cooking loss, emulsion stability, color

The emulsification stability of sausage is indirectly evaluated by water loss and fat loss. The effect of pork rind content on the cooking loss and emulsification ability of sausages is shown in Table 2.

The results in Table 2 show that the cooking loss of the pork rind-supplemented treatment group and the control group was significantly reduced (P<0.05). This phenomenon shows that adding pork rind can reduce cooking loss during the sausage heating process. Another study found that adding pork rind collagen to simulated cured meat products can reduce the cooking loss rate, which is similar to the results of this experimental study [26]. Cooking loss, moisture loss, and fat loss showed a significant downward trend with increasing pork rind addition (P<0.05). At the same time, the test results also showed that when the addition of pork rind was increased by more than 60 g, the cooking loss, moisture loss and fat loss showed an upward trend. Compared to the control group, the T3 treatment group had the lowest cooking loss, water loss, and fat loss (P<0.05). Bran-chicken sausage supplemented with 15 % pork rind (T3) showed lower cooking and fat loss.

Table 2

Effect of different pork rind content on the cooking loss and emulsification stability of raw meat emulsion

Treatment	Cooking loss, %	Moisture loss, %	Fat loss, %
Control	9.64±0.09*a*	9.51±0.10*a*	0.15±0.03*ab*
T1	9.02±0.13*a*	8.91±0.12*ab*	0.11±0.01*b*
T2	9.19±0.43*a*	9.08±0.43*a*	0.11±0.02*b*
T3	7.18±0.20*b*	7.10±0.18*c*	0.08±0.03*b*
T4	9.11±0.56*a*	8.94±0.48*ab*	0.17±0.07*ab*
T5	8.52±0.54*a*	8.26±0.57*b*	0.26±0.08*a*

Note: Means within a column with different letters are significantly different (p<0.05)

The influence of pork rind content on the color of meat paste and sausage is shown in Table 3.

Table 3

Effects of different pork rind content on the chromaticity of raw meat and chicken sausage

Treatment	L^*		a^*		b^*	
	Raw meat	Sausage	Raw meat	Sausage	Raw meat	Sausage
Control	56.88±0.39*b*	62.79±0.89*bc*	27.29±0.34*a*	23.15±0.08*a*	9.74±0.31*c*	10.37±0.21*d*
T1	57.80±0.93*b*	64.67±1.71*a*	18.60±0.17*d*	18.96±0.09*bc*	9.36±0.16*c*	11.75±0.08*c*
T2	58.00±0.97*b*	64.60±1.03*a*	21.11±0.37*c*	18.02±0.33*bc*	11.15±0.22*b*	12.92±0.37*a*
T3	61.24±1.28*a*	61.64±0.81*bc*	24.11±0.36*b*	17.89±0.22*bc*	11.92±0.22*b*	12.04±0.34*cd*
T4	61.65±1.29*a*	60.18±0.99*c*	18.75±1.03*d*	16.80±0.54*c*	11.34±1.14*b*	12.68±0.35*ab*
T5	61.96±1.48*a*	61.89±2.87*bc*	19.51±1.70*cd*	19.40±2.58*b*	11.13±1.03*b*	11.60±0.84*c*

The results in Table 3 show that the lightness value (L^* value) and yellowness value (b^* value) (p<0.05) of the sausage in the treatment group first increased and then decreased compared with the control group without pork rind. The redness value (a^*) decreased significantly (p<0.05). In addition, as more pork rind was added, the L^* and b^* values of minced meat and chicken sausage gradually increased, while the a^* value gradually decreased.

5. 2. Research results on the texture properties of sausage

People like the elasticity and firmness of sausages. The effect of pork rind content on the texture characteristics of sausages is shown in Tables 4, 5. It can be seen that with the increase in the amount of pork rind added, the recovery of raw minced meat was significantly reduced (P<0.05), and elasticity, chewiness, stickiness, hardness, and cohesiveness were significantly increased (p<0.05).

At the same time, the chewiness of the sausages in the test group was significantly reduced (p<0.05), except for T1, while the elasticity, recovery, and cohesiveness did not change significantly (p>0.05), and the hardness value increased significantly (p<0.05). A comprehensive comparison showed that the T3 treatment group had the best textural properties.

Table 4

Effect of different pork rind content on the texture of raw minced meat

Treatment	Hardness (N)	Springiness	Cohesiveness	Gumminess (N)	Chewiness (N)	Resilience
Control group	64.11±3.86[b]	0.22±0.07[d]	0.28±0.04[cd]	17.74±3.45[b]	14.14±2.22[b]	0.06±0.00[a]
T1	72.75±11.05[b]	0.51±0.15[bc]	0.36±0.05[bc]	26.23±7.21[b]	14.17±8.08[b]	0.05±0.00[b]
T2	72.73±14.72[b]	0.29±0.01[cd]	0.19±0.02[d]	13.25±2.23[b]	13.89±0.72[b]	0.03±0.00[c]
T3	86.43±6.81[a]	0.91±0.00[a]	0.61±0.05[a]	54.99±9.31[a]	50.03±8.61[a]	0.06±0.00[a]
T4	77.67±15.46[b]	0.39±0.25[bcd]	0.33±0.13[bc]	24.32±3.75[b]	10.04±7.88[b]	0.06±0.00[a]
T5	60.47±5.00[b]	0.44±0.09[b]	0.35±0.07[b]	21.50±5.92[a]	19.90±4.79[b]	0.06±0.01[a]

Table 5

Effect of different pork rind content on the texture of chicken sausage

Treatment	Hardness (N)	Springiness	Cohesiveness	Gumminess (N)	Chewiness (N)	Resilience
Control group	66.96±0.77[d]	0.74±0.40[a]	0.53±0.26[a]	45.41±2.97[c]	42.72±2.46[b]	0.03±0.00[a]
T1	100.23±13.04[c]	0.77±0.46[a]	0.66±0.39[a]	87.61±6.09[b]	93.54±5.27[a]	0.05±0.01[a]
T2	125.94±4.19[b]	0.53±0.40[a]	0.45±0.14[a]	131.10±16.83[a]	24.35±18.25[c]	0.10±0.08[a]
T3	156.44±22.52[a]	0.58±0.05[a]	0.27±0.04[a]	34.25±4.17[a]	25.15±2.76[c]	0.05±0.01[a]
T4	138.35±8.00[ab]	0.25±0.06[a]	0.15±0.01[a]	40.22±9.21[c]	28.06±5.87[c]	0.03±0.00[a]
T5	83.89±26.33[d]	0.71±0.43[a]	0.52±0.26[a]	38.75±11.46[a]	30.83±21.99[c]	0.06±0.03[ab]

5. 3. Research results on the distribution of water of sausage

As shown in Fig. 1, the NMR signal of the sausage was composed of three fluctuating peaks, which were divided into three water states according to these three peaks, which are expressed from left to right as hydration water (T2b), immobilized water (T21), and free water (T22). T2b is the bound water in which the polar groups on the surface of protein molecules are closely combined with water molecules, and T21 represents the water that does not easily flow between the muscle filaments, myofibrils, and cell membranes, accounting for most of the water in the muscle. T22 represents the free-flowing water existing in the extracellular space; differences in peak areas represent the proportion of water in different states. The ratio of each peak area calculated by low-field nuclear magnetic resonance inversion can reflect the proportion of water in different states in the sample, and the change in the peak area ratio can characterize the distribution state and flow migration of water in different states in the sample [27]. The contents of the three states of water were recorded as A2b, A21, and A22.

The relaxation times (T2) corresponding to hydration water, immobilized water, and free water in the treatment group ranged from 1 to 3 ms, 12 to 107 ms, and 240 to 650 ms, respectively. As shown in Fig. 1, compared with the control group, the relaxation time of hydration water and immobilized water in the experimental group with pork rind was shifted to a shorter relaxation time, whereas the relaxation time of free water was shifted to a longer relaxation time in the direction. The moving strengths of hydration water and immobilized water were not significant (p>0.05), but the relaxation time of free water shifted significantly. This shows that the fluidity of the original hydration water and immobilized water in the sausage was reduced, which may be because it was closely combined with the collagen of the pork rind. In addition, it can be seen from the results in Fig. 1 that the free water moved slowly and became water that did not flow easily. The results of A21 in Table 6 show that the difference between T1 and the control group was not obvious, but that of the other treatment groups was significantly higher than that of the control group. This result corresponds to the peak area shown in Fig. 1.

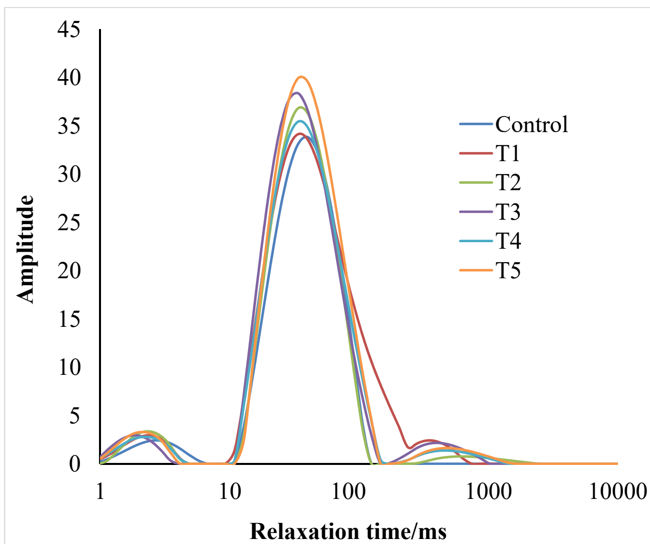

Fig. 1. Effects of pork rind additions on water distribution in chicken sausage

Table 6

Effect of different pork rind content on the dynamic distribution of moisture of sausage

Treatment	T2b (ms)	T21 (ms)	T22 (ms)	A2b	A21	A22
Control group	2.56±0.42*a*	40.73±6.61*a*	338.13±54.87*b*	2.32±0.12*c*	33.15±0.67*d*	0.77±0.14*e*
T1	2.17±0.35*a*	34.61±5.62*a*	468.27±75.99*b*	3.16±0.11*a*	33.52±1.14*d*	1.57±0.05*c*
T2	2.17±0.35*a*	34.61±5.62*a*	648.5±105.23*a*	3.14±0.26*a*	36.03±0.97*bc*	0.74±0.02*e*
T3	1.85±0.30*a*	34.61±5.62*a*	397.91±64.57*b*	2.81±0.12*b*	37.56±0.87*ab*	2.09±0.07*b*
T4	2.17±0.35*a*	34.61±5.62*a*	468.27±75.99*b*	2.69±0.10*b*	34.74±0.75*bc*	1.33±0.03*d*
T5	2.56±0.42*a*	34.61±5.62*a*	338.13±54.87*b*	2.78±0.20*b*	39.10±0.65*a*	2.28±0.16*a*

NMR imaging is a new method of non-destructive testing, which reflects the distribution of hydrogen protons in the sample by obtaining a proton density-weighted image inside the sample. Generally, the denser the hydrogen protons, the brighter the proton density-weighted image. Hydrogen protons are mainly derived from water molecules, and the brighter the proton density-weighted image, the higher the water content in the region.

The proton density-weighted pseudo-color image of chicken sausage with different pig skin contents is shown in Fig. 2.

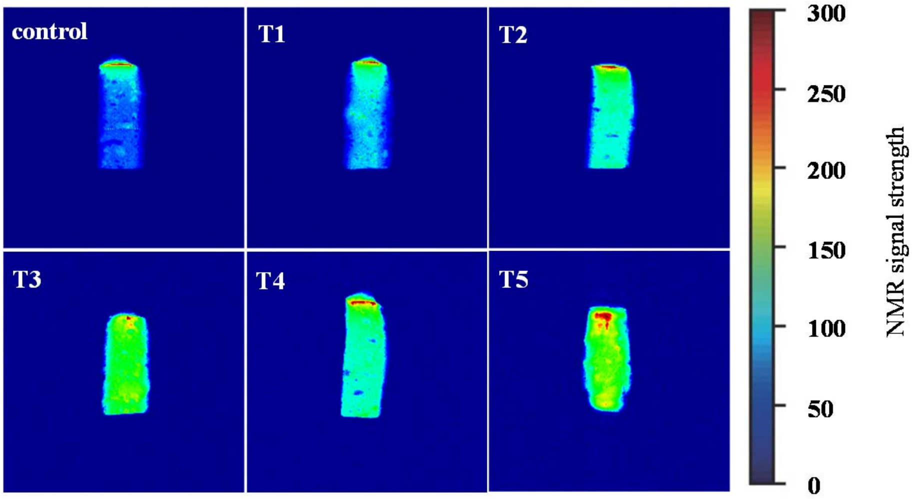

Fig. 2. Pseudo-color map of proton density-weighted imaging of chicken sausage with different pork rind content

Fig. 2 shows the distribution of water molecules in chicken sausages with different additions of pork rind. The strength of the *NMR* signal is proportional to the water content. The red area in the figure represents the strongest *NMR* signal and the highest water content, and the blue area represents the weakest *NMR* signal and the lowest water content. From Fig. 2, it can be easily seen that the higher the addition of pork rind, the higher the moisture content, which may be due to the fact that the collagen of the pork skin can be closely combined with ground chicken, which increases the water-holding capacity of the sausage.

5. 4. Research results on the sensory evaluation of sausage

The effect of pork rind content on the sensory evaluation of sausages is shown in Table 7.

Table 7

Effect of different pork rind content on the sensory evaluation score of sausage

Treatment	Color	Hardness	Flavor	Viscosity	Overall acceptance
Control group	4.30±1.49*a*	3.80±0.92*a*	4.20±1.99*a*	3.60±1.27*a*	4.10±1.08*a*
T1	4.10±0.88*a*	4.70±0.95*a*	4.90±1.79*a*	3.90±1.20*a*	4.20±1.03*a*
T2	4.30±1.42*a*	4.80±1.03*a*	5.20±0.92*a*	3.90±1.60*a*	5.40±1.17*a*
T3	4.30±1.42*a*	4.50±1.08*a*	5.10±1.29*a*	5.00±1.56*a*	5.40±1.43*a*
T4	5.30±1.16*a*	4.90±1.20*a*	5.40±1.27*a*	4.50±0.85*a*	4.40±1.25*a*
T5	5.00±1.49*a*	2.70±1.25*c*	4.50±0.85*a*	4.60±1.51*a*	4.10±1.37*b*

Sensory evaluation is the most widely used and effective classical method in product development. As shown in Table 7, the sensory scores of the sausages of the treated group were slightly higher than those of the untreated group in terms of color, hardness, flavor, viscosity, and overall acceptability, but the difference was not significant (p>0.05), indicating that the addition of pork rind helps to increase the firmness, flavor, and overall acceptance of the sausage. In summary, the sensory evaluation of the T3 treatment group was highest.

6. Discussion of the results of studying the effect of pork rind content on the quality of bran-chicken sausage

The effect of different additions of pork rind on the quality of bran chicken sausage in Tables 2, 4, 7 showed that the cooking loss, texture properties and sensory evaluation results of the sausage in the T3 treatment group (adding 15 % pork rind) were the best comprehensively. The results of previous studies have determined the amount of bran added. This study mainly focused on the quality characteristics of sausages and did not pay attention to the content of sausage nutrients.

Pork rind collagen has better water retention, which can significantly reduce the cooking loss of sausages in the treatment group and improve the cooking stability. The researchers' study showed that the fat substitute for frankfurter sausages had significantly lower cooking losses when a mixture of pork rind and wheat bran was used [13]. This may be due to the fact that pork rind itself has a high content of collagen, which can improve the water retention capacity and emulsification stability of chicken sausage. Similar to the research results of previous studies, the amount of emulsified collagen added and the emulsification stability of the samples are proportional [28]. The results in Table 2 showed that the cooking loss first decreased and then increased with the addition of pig skin. When 15 % pig skin (T3) was added, the cooking rate and fat reduction rate of wheat bran chicken intestines were lower. This result is different from the results of previous researchers, and the main reasons may be affected by the insufficient gelatinity of pig skin and the addition of bran.

The results in Table 2 showed that as the amount of pork rind increases, the color of the sausage becomes lighter. This phenomenon may be due to the fact that the addition of pork rind will dilute the original color when the content of other raw materials remains unchanged, resulting in a gradual decrease in the a^* value.

The TPA results of bran chicken sausage with pig skin added in this study are shown in Tables 4, 5. The results show that adding pig skin can improve the texture characteristics of sausage, which is similar to the results of other researchers. Such as: the authors' study showed that adding pork rind extract can improve the elasticity of sausage to a certain extent, and the texture properties of minced pork sausage with the addition of 6 % pork rind extract were optimal [29]. The researchers studied the effects of corn starch, pork rind homogenate, and fat on the quality of pork sausage, and found that when the addition of pork rind homogenate was approximately 6 %, pork sausage had good elasticity and tightness. The optimal dosage was lower than that used in this study (15 %) [30]. The researchers added pork rind-coconut flour gel to emulsified sausages, which can improve the texture characteristics of emulsified sausages and significantly improve their hardness, cohesiveness, and chewiness [14]. This also indicates that the collagen contained in pork rind can improve textural properties such as hardness and elasticity of sausage to a certain extent. The research results showed that the amount of emulsified pig skin was proportional to the hardness, elasticity, cohesion and chewiness of the product, which was consistent with the results of this study [31].

The researchers used proton density-weighted imaging to determine the water content in water-injected minced meat. The distribution was then visualized. The higher the moisture content in the sample, the stronger the signal of the proton density image [32]. The proton density-weighted imaging results in Fig. 2 in this study were similar to their results. The researchers used the changes in the bright and dark areas of a proton density image to study the dynamic changes in water distribution during soaking of rice seeds. The visualization of water distribution can judge the combination effect of water and chicken fiber, and the water absorption of sausage.

In the water distribution research part, the size of the T2 peak area in Fig. 1 is consistent with the results in Table 6. Previous researchers used a vegetable oil pre-emulsion to replace animal fat in frankfurters. The results showed that when the fat replacement amount reached 45 %, the results of A2b and A21 increased significantly compared with those of the control group, which was consistent with the results of this study [21].

From Table 7 Results of sensory evaluation, although panelists preferred the color, firmness, and flavor of the T4 treatment group, the T3 and T2 treatment groups had the highest overall scores. This may be because the gel properties of the pork rind were too strong when adding 80 g of pork rind to the sausage. The sausage was too firm in texture and affected overall acceptability and flavor.

The pre-cooking time of pork rind determines the dissolution amount of collagen, and has a significant impact on the texture properties and water retention of sausages. The cooking process of pork rind needs to be determined for industrial applications.

In our research, although the quality characteristics of sausage and the application of pig skin were solved, how to obtain pig skin and how to remove pig hair well requires huge labor costs. In addition, how the effect of granular collagen produced in the food industry on sausage quality differs from that of pig skin requires further attention.

7. Conclusions

1. The addition of pork rind reduced the cooking loss of bran chicken sausage and improved emulsion stability. In particular, the cooking loss in all treatment groups was improved by the addition of pork rind. As more pork skin was added, the L^* and b^* values of the minced meat and chicken sausages increased gradually, manifesting as an increase in brightness and yellowness.

2. In terms of texture characteristics, the addition of pork rind significantly improved the hardness of sausages. In addition, we found that the six texture characteristics of the T3 test group (60 g pork rind added to 400 g chicken) had the highest values.

3. In terms of water distribution characteristics, the study found that adding pork rind improved the water-holding capacity of chicken fibrin, and the semi-bound water content increased with an increase in pork rind addition. This phenomenon was more intuitively demonstrated using proton density-weighted imaging.

4. In terms of the sensory evaluation of the product, the overall acceptable score results of the evaluation panel members indicated that the T3 test group was the best. In conclusion, adding 15 % cooked pork rind to bran chicken sausage can improve the cooking loss, textural properties, and sensory quality of sausages. The results of this study provide data support for the development of low-fat, high-fiber, and nutritionally balanced chicken sausages while improving the utilization and added value of pork rind.

Conflict of interest

The authors declare that they have no conflict of interest in relation to this research, whether financial, personal, authorship or otherwise, that could affect the research and its results presented in this paper.

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