

# Effect of quantitative brine process and curdlan gel on texture quality of spiced beef

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## ABSTRACT

In order to solve the problems of loose texture and low quality of brined beef in the actual production process, this study took beef tendon as raw material, firstly, carried out the study of quantitative brining process to determine the optimal brining process; then, used the brine injection technique to add curdlan gel, and then used texture profile analysis (TPA) to study the effect of different types and amounts of curdlan gel (0%, 1%, 2%, 3% and 4%) on the textural properties of the brined beef. (TPA) was used to study the effects of different types and amounts of curdlan gel (0%, 1%, 2%, 3% and 4%) on the textural properties of brined beef. The optimum quantitative brining conditions for brined beef were determined by one-way and orthogonal tests: marinating time of 6 hours, brining time of 40 minutes and simmering time of 20 minutes, which gave the highest overall acceptability score. The results of the test calculations showed that the content of curdlan gel No. 1 was 71% and the content of curdlan gel No. 2 was 45%. The results of texture analysis showed that the hardness, stickiness and chewiness of the brined beef in the group added with curdlan gel gum No.1 decreased significantly ( $P < 0.05$ ), while the changes of elasticity, cohesiveness and reactivity were not significant ( $P > 0.05$ ); the hardness of the brined beef in the group added with curdlan gel gum No.2 increased slightly, and the changes of stickiness, chewiness, elasticity, cohesiveness and reactivity were not significant ( $P > 0.05$ ), indicating that the hardness of meat products did not necessarily just show a decreasing trend with the increase of the content of curdlan gel gum. After comprehensive analysis, it was concluded that, since the content of the available natural gum No.1 was significantly higher than that of No.2, the effect on the texture was also significantly higher than that of No.2, among which the effects on hardness, viscosity and chewiness were significant ( $P > 0.05$ ). Moreover, regardless of the curdlan gel No.1 or No.2, the overall analysis revealed that the effect on the texture of marinated beef was the greatest when the added amount of curdlan gel gum was 2%. Therefore, the addition of appropriate amount of curdlan gel gum during the processing of marinated meat products can effectively improve the quality of meat and prolong its shelf-life.

## KEYWORDS

Saline injection technique; Curdlan gel; Quantitative brine process; Texture

## 1. INTRODUCTION

### 1.1. Significance Of The Study

The relevant survey found that beef is the third largest consumption of meat after pork and poultry [1]. Its total annual consumption can reach more than 10 million tonnes, accounting for about 25% of the entire meat products market [2]. Beef is rich in high quality protein, but the fat content is very

low, so the overall nutritional value is very high, in the market by the consumer favour, The overall nutritional value of beef is very high, and it is favoured by consumers in the market [3]. Beef as a raw material after brining the marinated beef has a strong flavour, rich in nutrients and other characteristics, has always also been favoured by the majority of consumers [4].

In the traditional meat processing in the past, most food companies usually choose to use polyphosphates, nitrates, sorbic acid and its salts, etc [5], to enhance the quality of meat products. However, if these chemically synthesised food additives are consumed by humans in excessive amounts over a long period of time, they will cause serious harm to their health [6]. With the implementation of the "Healthy China 2030" programme and the increasing awareness of people's health, green and healthy meat products are bound to receive widespread attention from society and consumers [7]. Therefore, the use of green and natural food additives in beef products is an important research topic in the field of meat products science.[8] In this regard, Cortex Gum is a new type of natural food additive.

Curdlan gel, also known as thermogel or agglutinative polysaccharide, consists of glucose monomers linked by linear  $\beta$ -(1,3) glycosidic bonds [9]. Its suspension can form a colourless, odourless gel by heating, and its aqueous suspension can form 2 different structural types of gels at low and high temperatures, called low-solidifying thermoreversible gels (TRC) and high-solidifying thermo-irreversible gels (TIRC), respectively [10]. After a long period of testing and research, the U.S. Food and Drug Administration permitted the application of TRC in food as a food additive in 1996, and then the Ministry of Health of China also approved the application of TRC in food in 2006, Later in 2006, China's Ministry of Health also approved the application of curdlan gel in food field[11]. Compared with other hydrophilic colloids, it has its own unique characteristics such as anti-dehydration, thermal stability, and so on [12]. Jiang Shuai et al [13], in a study on the addition of 0.3% of curdlan gel gum to Frankfurter sausages with different water contents, the results showed that curdlan gel gum could significantly improve the organoleptic quality of the sausages at a higher water content. Chen Conggui et al [14], it was found that the hardness and viscoelasticity of meat were significantly improved by adding appropriate amount of carrageenan to high-pressure duck gel, and the internal gel structure became denser, which effectively improved the quality characteristics of duck products. Hsu et al [15], it was found that the textural properties of meatballs, such as viscoelasticity and chewiness, could be improved by the use of curdlan gel gum compared with carrageenan. Fan Lixin et al [16], it was found that the addition of 0.3% to 0.4% of curdlan gel gum to minced fish by preemulsification could significantly improve the juiciness and gelation characteristics of minced fish products, and the whiteness value of the products could also be significantly improved. How to improve the quality of corned beef has become one of the hot topics in the food industry nowadays, while the good freeze-thaw stability and strong water-holding property of curdlan gel is a good research direction, and the study of curdlan gel on the improvement of corned beef texture has certain practical significance.

Quantitative brining refers to a process that completes brining through the precise modulation of raw meat and brining liquid, which is characterised by high production efficiency and enables the standardised production of beef in sauce and marinade [17]. It has the characteristics of high production efficiency and can achieve the standardised production of beef in sauce and brine. Wen Lijuan et al [18], the quantitative brining technique was used to determine the optimal processing parameters of brined beef.

The texture of corned beef is one of the most important factors affecting its quality, and instrumental determination is an important means of evaluating the texture of corned beef [19]. The texture profile analysis (TPA) method is to simulate the chewing action of human mouth through the probe of texture instrument, to find out the texture indexes such as hardness, elasticity, responsiveness, cohesiveness, viscosity and chewiness which correspond to the human sensory evaluation [20, 21].

The main purpose of this experiment is to investigate the effect of curdlan gel on the textural properties of corned beef by saline injection technique, which can provide reference value for shortening the processing time of corned beef, increasing the yield and reducing the production cost.

## **1.2. Progress In National (Domestic) And International Research**

In recent years, curdlan gel has become popular in the market as one of the new food additives, which is widely used in various meat processing fields. Nowadays, there is an increasing demand for curdlan gel in both domestic and foreign markets. Although some biotechnology companies in China, such as Jiangsu Yiming Biological Co., Ltd. have initially realised large-scale industrial production of curdlan gel and widely used it in the field of foodstuffs, there are still a lot of challenges during the actual production process, such as the high cost of production and the low yield, etc., which are yet to be solved, however, there are still many challenges in the actual production process, such as high production cost, low yield and other difficulties have not been solved [7].

## **1.3. Entry Points For This Study**

Using quantitative brining methods, the effects of marinating time, brining time and simmering time on the organoleptic quality of brined beef were investigated to determine the optimal brining process; on the basis of the optimal process, attempts were made to investigate the effects of curdlan gel gum No.1 and No.2 on the textural properties of brined beef.

## **1.4. Key Issues To Be Addressed**

Using quantitative brining techniques, the optimal brining process was determined based on the effects of marinating time, brining time and simmering time on the organoleptic quality of brined beef; the preparation and injection of injection solution; and the selection of suitable texture test methods based on the test conditions to clearly evaluate the effects of curdlan gel gum No.1 and No.2 on the textural properties of brined beef.

# **2. MATERIALS AND METHODS**

## **2.1. Experimental Materials**

### **2.1.1. Materials**

#### **(1) Raw materials**

Beef tendon (100g per group), Curdlan gel (Shandong Duiyuan Yikang Biotechnology Co.)

## (2) Accessories

**Table 1.** Main accessories

Pseudolaric acid	norm	Place of Origin/Manufacturer
salt	food grade	Shandong Province Luyan Group Co.
sugar	food grade	Angie's Yeast (Chifeng) Co.
diphosphate	food grade	Xuzhou Haicheng Food Additives Co.
laurel leaf	food grade	Bozhou Bingfu Agricultural Development Co.
Sichuan pepper	food grade	Yulin Shengdingju Original Chinese Herbal Medicine Co.
Chinese cinnamon	food grade	Bozhou Bingfu Agricultural Development Co.
aniseed	food grade	Bozhou Bingfu Agricultural Development Co.
licorice	food grade	Yulin Shengdingju Original Chinese Herbal Medicine Co.
angelica	food grade	Yulin Shengdingju Original Chinese Herbal Medicine Co.
lilac	food grade	Yulin Shengdingju Original Chinese Herbal Medicine Co.
light soy sauce	food grade	Foshan Haitian Seasoned Food Co.
dark soy sauce	food grade	Foshan Haitian Seasoned Food Co.
chicken essence	food grade	Shanghai Wifejoy Fuzite Foods Co.
cooking wine	food grade	Foshan Haitian Seasoned Food Co.

### 2.1.2. Instrumentation

**Table 2.** Main instrumentation

Instrument name	model number	Place of Origin/Manufacturer
Vacuum Pickling Machine	KA-6189A	Shenzhen Ruifeng Electric Co.
Electronic Analytical Balance	ACS-30kg	Shanghai Ranhao Electronics Co.
steamer		Chaozhou Chaoan District Dongfeng Town Wanda Tong Electrical Appliance Factory
SMS mass spectrometer (UK)	TA.XT Plus Type C	Stable Micro Systems, UK
spectrophotometer		Shanghai Prism Technology Co.

## 2.2. Experimental Methodology

### 2.2.1. Experimental design

#### (1) Quantitative brining process

In the experiments, the effects of marinating time, brining time and simmering time on the colour, texture and aroma of marinated beef were investigated based on the basic recipe quantities, and a one-way test was set up to find out the ranges of marinating time, brining time and simmering time according to the results of the one-way test, and then the optimal combination of the final process was obtained by orthogonal test.

#### (2) Textural analyses

The effect of curdlan gel No.1 and No.2 on the textural properties of brined beef was investigated on the basis of the optimal combination process.

## 2.2.2. Measurement methods

### (1) Determination of curdlan gel content

According to the determination method in the national food safety standard GB 28304-2012, the content of curdlan gel can be calculated according to (1):

$$w_2 = \frac{A_T}{A_s} \times \frac{0.9 \times m_s}{m_T} \times 100\% \quad (1)$$

Style:

$A_T$ -absorbance value of the sample solution

$A_s$ -absorbance value of the standard solution

0.9-ratio of anhydrous glucose molecular mass to glucose molecular mass

$m_s$ -value of the amount of glucose weighed during the preparation of the standard solution in milligrams (mg)

$M_T$ -value of the sample mass in milligrams (mg)

According to the food safety national standard GB 28304-2012 in the determination of the content of curdlan gel, measured by spectrophotometer: the absorbance value of the blank solution is 0.196; the absorbance value of the sample solution containing curdlan gel No.1 is 0.574; the absorbance value of the sample solution containing curdlan gel No.2 is 0.363; the absorbance value of the standard solution is 0.728;

This is obtained by bringing it into equation (1):

Curdlan gel No. 1:

$$w_2 = \frac{A_T}{A_s} \times \frac{0.9 \times m_s}{m_T} \times 100\% = \frac{0.574}{0.728} \times \frac{0.9 \times 100}{100} \times 100\% \approx 71\%$$

Curdlan gel No. 2.

$$w_2 = \frac{A_T}{A_s} \times \frac{0.9 \times m_s}{m_T} \times 100\% = \frac{0.363}{0.728} \times \frac{0.9 \times 100}{100} \times 100\% \approx 45\%$$

Thus, a content of 71 per cent can be obtained for curdlan gel No.1 and 45 per cent for curdlan gel No.2.

### (2) Texture determination

According to the process parameters of the previous test, in the most suitable scheme, the cooked beef blocks were naturally cooled to room temperature, and the meat samples of each group were trimmed into 1.5 cm × 1.5 cm × 1.5 cm blocks in the direction of muscle fibre, based on the research method of Zhao Jiayi et al [22], the hardness, resilience, cohesion, elasticity, stickiness, and chewiness of the five groups of samples were measured at room temperature using a TA-XT plus texture analyser. The parameters were as follows: probe model P/36R, pre-test rate of 1 mm/s, mid-test rate of 1 mm/s, post-test rate of 1 mm/s, interval time of 5 s, data collection rate of 200 points/s, compression ratio of 50%, trigger force of 5.0 g, and trigger type of auto. The measurements were repeated three times for each sample, and the results were averaged.

### (3) Sensory evaluation methods

The organoleptic evaluation criteria refer to Feng Wei's method [23], the method was based on the evaluation indexes of colour, taste, palatability, aroma and elasticity, and 10 professional sensory

evaluators were invited to carry out sensory evaluation of the marinated beef through the senses of vision, smell, touch and taste, and the sensory evaluation criteria are shown in Table 3.

**Table 3.** Sensory evaluation form

sports event	Scoring content	Points/points
	Uneven colour and poor gloss	1 to 5
colour	Colour is more uneven and less glossy	6 to 10
(20 points)	Colour is more uniform, shiny and inconspicuous	11-15
	Uniform colour, glossy and bright reddish-brown.	16-20
	Strong smell, too strong or too light taste, strange marinade taste	1 to 5
flavours	Vaguely fishy, slightly over-salted or overly light flavour, and disharmonious brininess.	6 to 10
(20 points)	No off-flavour, suitable saltiness, harmonious marinade taste	11-15
	No off-flavour, good saltiness, rich marinade flavour	16-20
	The meat is dry, hard or too soft and chewy.	1-5
palatability	The meat is dry or soft and chewy.	6-10
(20 points)	The meat is soft and firm, less juicy and more chewy	11-15
	The meat is tender and chewy	16-20
	Strong steaming taste and odour	1-5
incense	The marinade is light in aroma and has an off-flavour	6 -10
(20 points)	The marinade has a light aroma and no off-flavour	11-15
	The marinade is aromatic and full-bodied.	16-20
	Flesh cuts are uneven and do not spring back under finger pressure	1-5
resilient	Meat cuts are uneven, slow and poorly resilient to finger pressure	6-10
(20 points)	The meat cuts are uneven and have a moderate degree of quick rebound under finger pressure.	11-15
	Flat cuts of meat, quick rebound under finger pressure	16-20

#### (4) Methods of data counting

Correlation analysis with ANOVA was performed using SPSS Statistics 26.0 and plotted using EXCEL 2021 tabulation and Origin 2019.

#### 2.2.3. One-way test for optimisation of brined beef process

##### (1) Curing time

The marinating time was controlled as 3h, 4h, 5h, 6h and 7h respectively.

##### (2) Brining time

Separately control the brining time for: 20min, 30min, 40min, 50min, 60min.

##### (3) Simmering time

Control the simmering time: 10min, 15min, 20min, 25min, 30min.

#### 2.2.4. Orthogonal test for optimisation of marinated beef process

On the basis of the one-way test, four factors, namely marinating time (A), brining time (B), simmering time (C), and empty column (D), were selected to conduct a four-factor, three-level orthogonal test by means of a sensory rating scale as an evaluation index, and the orthogonal test is shown in Table 4.

**Table 4.** Table of orthogonal factors and levels

level (of achievement etc)	A: Curing time (h)	B: Brining time (min)	C: Simmering time (min)	D: Empty columns
1	5	30	15	1
2	6	40	20	2
3	7	50	25	3

#### 2.2.5. One-way test of the effect of curdlan gel on texture and structure

Each set of samples was 100g of beef tendon meat, and five sets of variables were set for each sample.

Curdlan gel No.1: 0%, 1%, 2%, 3%, 4%

Curdlan gel No.2: 0%, 1%, 2%, 3%, 4%

#### 2.2.6. Experimental steps

##### (1) Pre-treatment of raw meat

The beef tendon meat was first thawed in running water and then trimmed to trim excess fat, lymph and impurities such as broken bones, cleaned and then cut into cubes of size 3 cm × 3 cm × 3 cm, divided into roughly 100 g per piece size, and 3 parallels were made for each group.

Set three factors of marinating time (3h, 4h, 5h, 6h, 7h), brining time (20min, 30min, 40min, 50min, 60 min), and simmering time (10min, 15min, 20min, 25min, 30min) to conduct one-way experiments, and select 10 evaluators with sensory evaluation ability to determine the most influential factors according to the sensory evaluation of the Based on the results of the sensory evaluation, the factors with the greatest influence were determined, and an orthogonal design was carried out to obtain the sensory optimal process combination, and then subsequent experiments were carried out.

##### (2) Injection preparation and injection

Firstly, mix the curdlan gel, salt, sugar and compound phosphate evenly and add to ice water, stirring until no visible particles.

**Table 5.** Marinade recipe (based on 100g beef)

Raw and auxiliary materials	Amount used/g	Raw and auxiliary materials	Amount used/g
curdlan gel No.1 and No.2	0, 1, 2, 3, 4	diphosphate	1
acidifier	4	(refined) white sugar	1.2
ice water	40		

Referring to Jia Na et al [24], The method of injecting marinated beef was improved by compounding the edible gum with brine, and its optimal injection rate of 25% was finally obtained. The marinated meat products treated by the injection technique not only became tender and fluffy, but also could reach the level of rapid marination, so as to achieve the purpose of maintaining the basic nutrients of the meat and strengthening the edible taste, and at the same time improving the quality of the meat products [25].

### (3) Tumbling marinade

Salt water syringe injects the marinade evenly into the treated beef cubes, puts them into the vacuum tumbler, and seals and evacuates them until the vacuum level is -0.06MPa [26]. Using the mechanical action of tumbling to treat beef can make the salt-soluble proteins inside the meat move rapidly to the surface layer of the meat, so that the yield can be effectively improved, and will largely improve the tenderness, water retention, texture and other organoleptic qualities of the beef [27]. Compared with the traditional standing marinade, tumbling marinade is characterised by fast marinade rate, enhanced water retention and improved meat tenderness [28].

### (4) Brining

Put cinnamon, fennel, star anise, peppercorns, allspice and cloves into a pulveriser for crushing, after crushing, put the powder into gauze wrapping to make a packet; then boil large-sized water, add soya sauce, dark soy sauce, chicken essence, cooking wine, green onion and the prepared packet to the boiling water, and keep it at a slight boil for 30 minutes on a low flame, then add beef, and control the temperature of the water in the range of 90-95°C to boil it.

**Table 6.** Formula of cooking spices (based on 100g beef)

raw and auxiliary materials	Amount used/g	raw and auxiliary materials	Amount used/g	raw and auxiliary materials	Amount used/g
acidifier	30	rock candy	20	spring onion	30
aniseed	3	fennel (Foeniculum vulgare)	3	dark soy sauce	25
Sichuan pepper	3	angelica (type of iris)	3	chicken essence	10
Chinese cinnamon (Cinnamomum cassia)	3	lilac (Syringia vulgaris)	3	cooking wine	40
laurel leaf	1	light soy sauce	40	ice water	2000

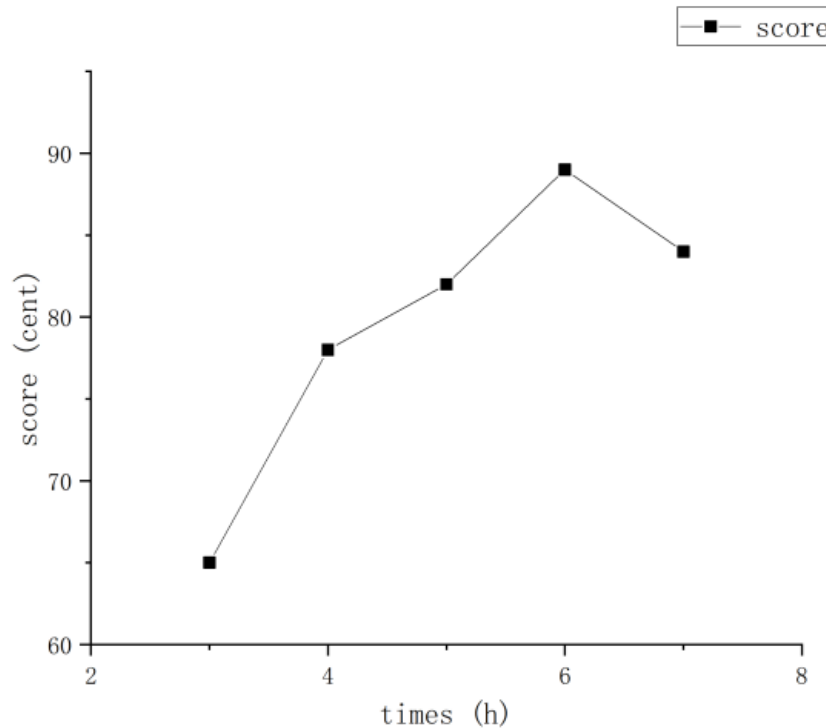
### (5) Texture analysis

Determine the mass composition according to 2.2.2.2.

### 3. CONCLUSIONS AND ANALYSES

#### 3.1. Analysis Of One-Factor Results Of Process Optimisation Of Brined Beef

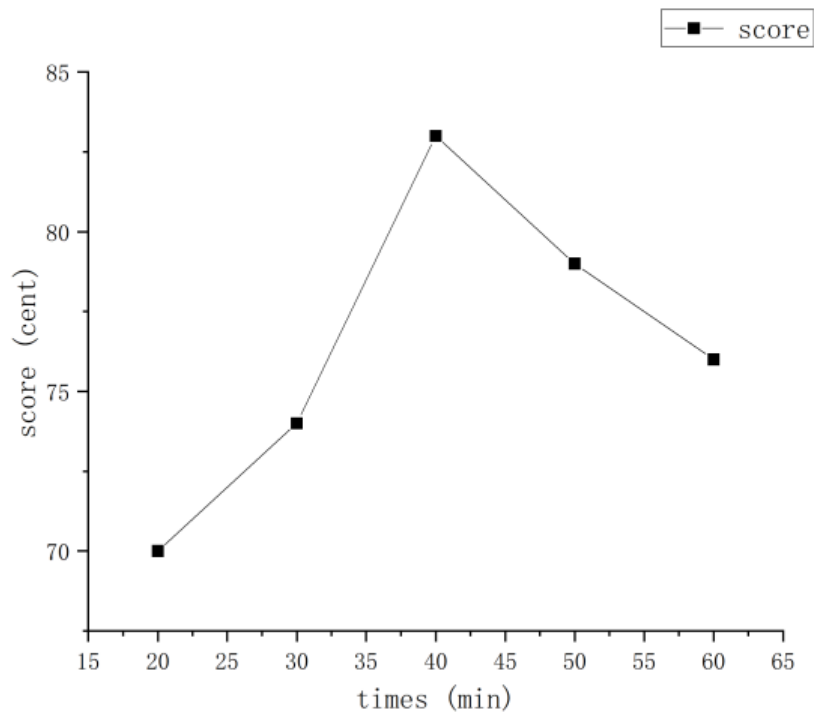
##### 3.1.1. Effect of different marinating time on the quality of marinated beef



**Figure 1.** Changes in sensory quality of brined beef under different marinating time

As can be seen from Figure 1, the highest sensory score of 89 was obtained for marinated beef marinated for 6 hours. The organoleptic quality of brined beef increased significantly ( $P < 0.05$ ) with the increase of marinating time during 3-6 hours, and the best quality of beef was achieved at 6 hours of marination, however, the organoleptic quality of beef decreased with the increase of marinating time. Too short a marinating time would lead to insufficient flavour and soft texture of marinated beef, but too long a time would lead to too salty flavour and woodiness of the meat, and the sensory quality would be reduced again [29]. Therefore, the optimum marinating time for corned beef was selected to be 6 hours.

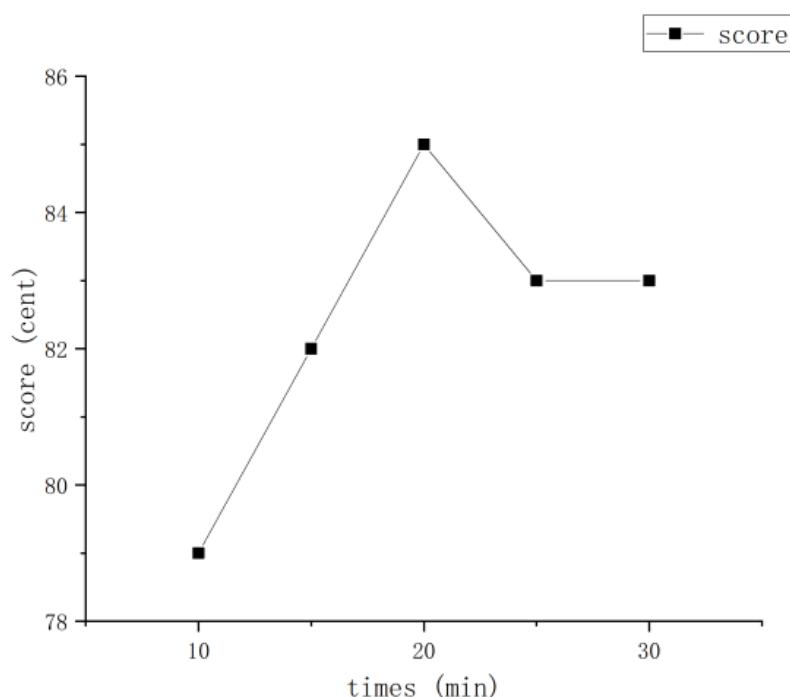
### 3.1.2. Effect of different brining times on the quality of brined beef



**Figure 2.** Changes in sensory quality of brined beef under different brining times

As can be seen from Figure 2, the highest sensory score of 83 was obtained when the brined beef was brined for 40 minutes. Within 20-40 minutes of brining, with the extension of brining time, probably with the gradual dissipation of water from the beef, the hardness became smaller, and the sensory score gradually increased, and the best quality of beef was reached at 40 minutes of brining; however, with the continual extension of brining time, the sensory quality of brined beef showed a decreasing trend, probably due to the fact that with the extension of brining time, the myofibrillar protein of the beef was continuously contracted, and the muscle tissue structure was destroyed and the structure became loose [30, 31]. The appropriate brining time is conducive to the retention of more fatty acids, and the results of the study showed that the brining time had a significant effect on the quality of beef, and in order to obtain a better eating quality, 40 minutes of brining was selected as the optimal quality point for comprehensive consideration [32].

### 3.1.3. Effect of different simmering time on the quality of marinated beef



**Figure 3.** Changes in sensory quality of marinated beef under different simmering time

As can be seen from Figure 3, the highest sensory score of corned beef was 85 at 20 minutes of simmering. When the simmering time was 10-20 minutes, the organoleptic quality of corned beef had a greater tendency to increase positively, while it firstly showed a decreasing trend from 20-30 minutes and then levelled off. The results of the study showed that the simmering time had a significant effect on the quality of beef, and in order to obtain better eating quality, 20 minutes of simmering was selected as the optimal quality point for comprehensive consideration [32].

### 3.1.4. Results of orthogonal tests for process optimisation of brined beef

As analysed above, the optimum time for marinating is 6 hours, for brining is 40 minutes and for simmering is 20 minutes. Therefore, marinating time (A) 5 hours, 6 hours, 7 hours, brining time (B) 30 minutes, 40 minutes, 50 minutes and simmering time (C) 15 minutes, 20 minutes, 25 minutes were selected for orthogonal test.

**Table 7.** Orthogonal test results

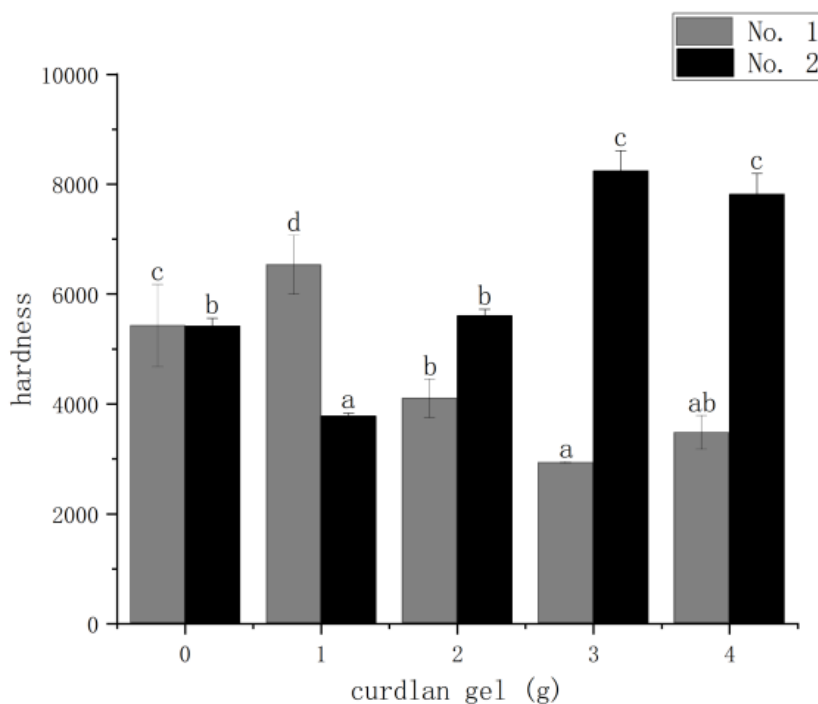
experiment number	A	B	C	blank column	Sensory score/ingredient
1	1	3	3	3	70
2	1	1	1	1	65
3	1	2	2	2	81
4	2	1	3	2	76
5	2	3	2	1	80
6	2	2	1	3	82
7	3	2	3	1	75
8	3	3	1	2	73
9	3	1	2	3	74
k1	72	71.667	73.333	73.333	
k2	79.333	79.333	78.333	76.667	
k3	74	74.333	73.667	75.333	
R	7.333	7.666	5	3.334	

The R-value in the fourth column is 3.334, while the calculated R of extreme variance for factors A,B,C are 7.333, 7.666, and 5, respectively, which are greater than the R-value in the fourth column, indicating that there is a difference in the level effect of factors A, B, and C.

The sensory results of the orthogonal test in Table 7 show that the order of the role of the factors is B>A>C. The relationship between the level values of each factor is as follows: A<sub>2</sub> >A<sub>3</sub> >A<sub>1</sub>; B<sub>2</sub> >B<sub>3</sub> >B<sub>1</sub>; C<sub>2</sub> >C<sub>3</sub> >C<sub>1</sub>, and the combined k value, as well as intuitive comparisons, resulted in the optimal combination of A<sub>2</sub>B<sub>2</sub>C<sub>2</sub>. Evaluating the order of the effect of each factor on the organoleptic quality of the brined beef, the most influential factor on the organoleptic quality of the brined beef was the corning time, followed by brining time, and finally the simmering time. The most significant effect on the organoleptic quality of corned beef was the marinating time, followed by the brining time and finally the simmering time. This leads to the conclusion that the optimum brining process for corned beef is 6 hours for marinating, 40 minutes for brining and 20 minutes for simmering .

### 3.2. Results Of Texture Analysis

#### 3.2.1. Effect of curdlan gel No.1 and No.2 on the hardness of marinated beef



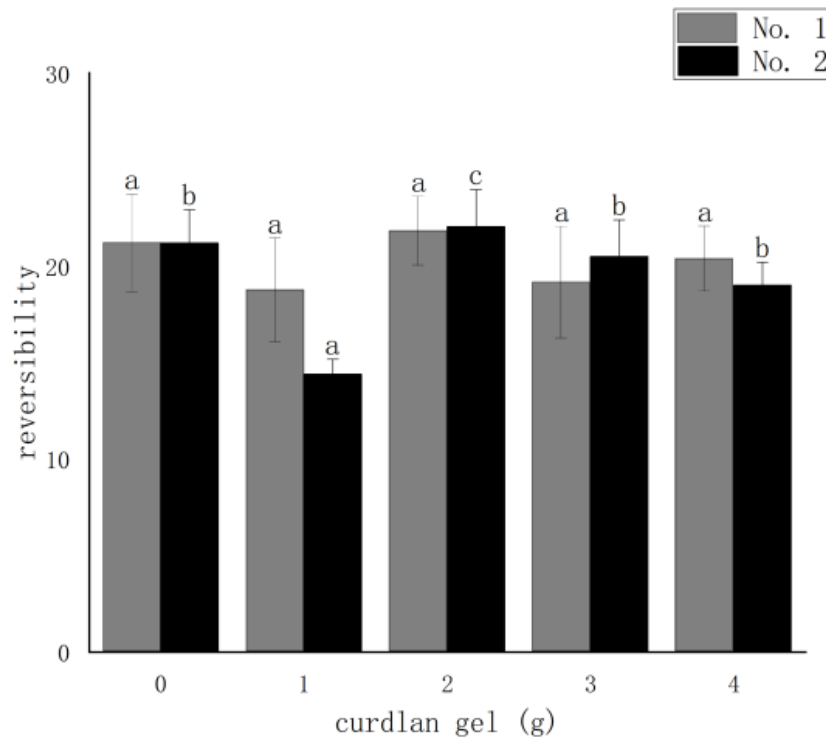
**Figure 4.** Influence of the amount of added curdlan gel on hardness

As can be seen from Fig.4, the hardness of brined beef showed an overall trend of increasing and then decreasing with the increase of the added amount of curdlan gel No.1, and reached the peak at the added amount of 1g, at which the hardness was about 1.2 times of that at the time of 0g, and then the hardness of brined beef was significantly reduced with the increase of the added amount ( $P<0.05$ ), which may be closely related to the strong water absorbency of the curdlan gel [33]. And may also be due to the fact that the excessive amount of curdlan gel will increase the PH of the meat, which will cause the protein to deviate from the original isoelectric point, making the fibre structure of the meat become loose, and ultimately causing a decrease in the hardness of the beef.

The hardness of brined beef decreased at 0-1g of curdlan gel gum No.2, probably due to the interaction between protein molecules to form a three-dimensional network structure with the unfolding of the advanced structure of myofibrillar protein during brining and heating, but the protein network structure is limited to retain water, so too much water could not be retained and lost, which

would make the hardness decrease [34]. The hardness of myofibrillar protein gels increased gradually at 1-3g, which may be due to the fact that polysaccharide molecules and myofibrillar protein can cross-link with each other to form a more dense and stable three-dimensional network structure during the heating process, which improves the hardness of myofibrillar protein gels [35]. The hardness of myofibrillar protein gels reached the peak at 3g, the hardness of beef was the lowest at 1g, and decreased again at 3-4g, but the decrease was small, and the hardness was relatively smooth on the whole. Taken together, it can be concluded that the effect of the hardness of marinated beef was best when the amount of curdlan gel added was 2g.

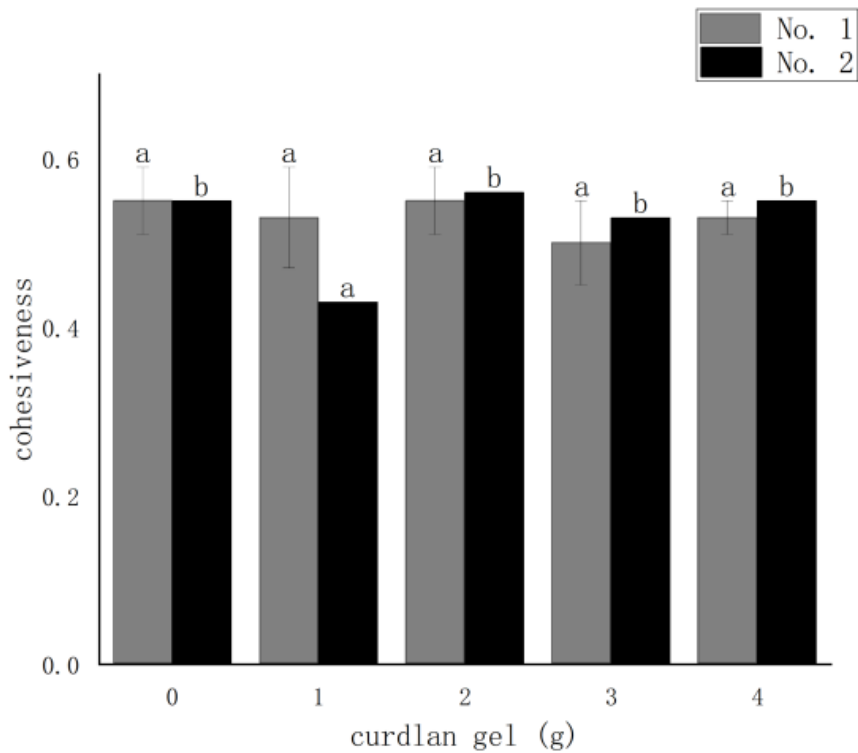
### 3.2.2. The effect of curdlan gel No.1 and No.2 on the restorative properties of brined beef



**Figure 5.** Influence of the amount of curdlan gel added on reversibility

Responsiveness indicates the extent to which deformed meat responds [36]. The As can be seen in Fig.5, the effects of curdlan gel No.1 and No.2 on the restorative properties of corned beef can be obtained similarly. During the whole test period, the restorative properties of brined beef with 1g addition were significantly ( $P < 0.05$ ) lower than the other four groups, while the restorative properties of brined beef with 2g addition showed a higher trend than the other groups. The results of this study suggest that the addition of 2g of curdlan gel to beef can significantly improve the restorative properties of beef.

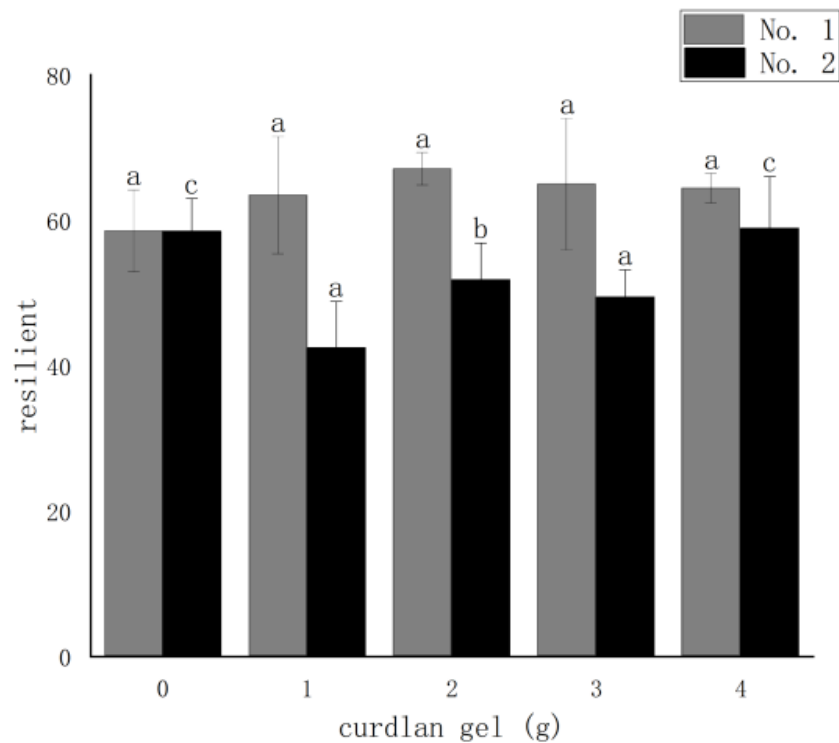
### 3.2.3. Effect of curdlan gel No.1 and No.2 on the cohesion of brined beef



**Figure 6.** Influence of additive amount of curdlan gel gum on cohesiveness

As can be seen from Fig.6, the effects of curdlan gel No.1 and No.2 on the cohesiveness of brined beef were similar. The overall change in the cohesiveness of beef was not significantly different ( $P > 0.05$ ) with the rise in the addition amount of curdlan gel No.1 and No.2. Zhang Hailong et al [37] showed that the gel strength of the same concentration of curdlan gel was higher than that of agar, and its gel properties were similar to those of agar brittleness and gelatin ductility, and the curdlan gel gum was more superior than other colloids in improving the deterioration of the product quality due to the excessive addition of water. The cohesion is related to the structure of the protein matrix inside the sample molecules, and the cohesion will be reduced by the weak linkag [38]. Overall, the cohesive property of curdlan gel gum No.1 and No.2 at 2g was greater than that at 0g, and the results were similar.

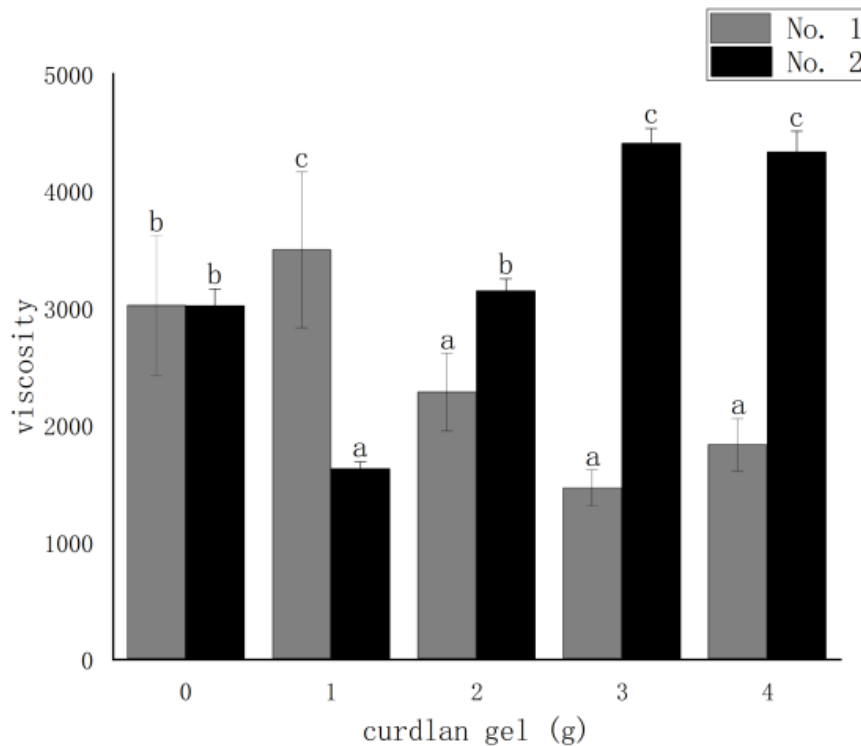
### 3.2.4. Effect of curdlan gel No.1 and No.2 on the elasticity of marinated beef



**Figure 7.** Influence of additive level of curdlan gel gum on resilient

As can be seen from Fig.7, the overall change of the effect of curdlan gel 1 on the elasticity of brined beef was not significant ( $P>0.05$ ), but in general, the effect of curdlan gel No.1 was better than that of curdlan gel No.2. With the increase of the added amount of curdlan gel No.1, the elasticity of meat samples showed an overall increasing trend, which was relatively smooth, probably due to the fact that polysaccharide molecules and myofibrillar protein can cross-link with each other to form a more dense and stable three-dimensional network structure during the heating process, which improved the elasticity of myofibrillar protein gels [35]. However, with the increase of the addition of curdlan gel gum No.2, the elasticity of brined beef was negatively affected, but the effect was not significant. Generally speaking, the effect of the elasticity of curdlan gel No.1 was better than that of curdlan gel No.2 on the elasticity of brined beef.

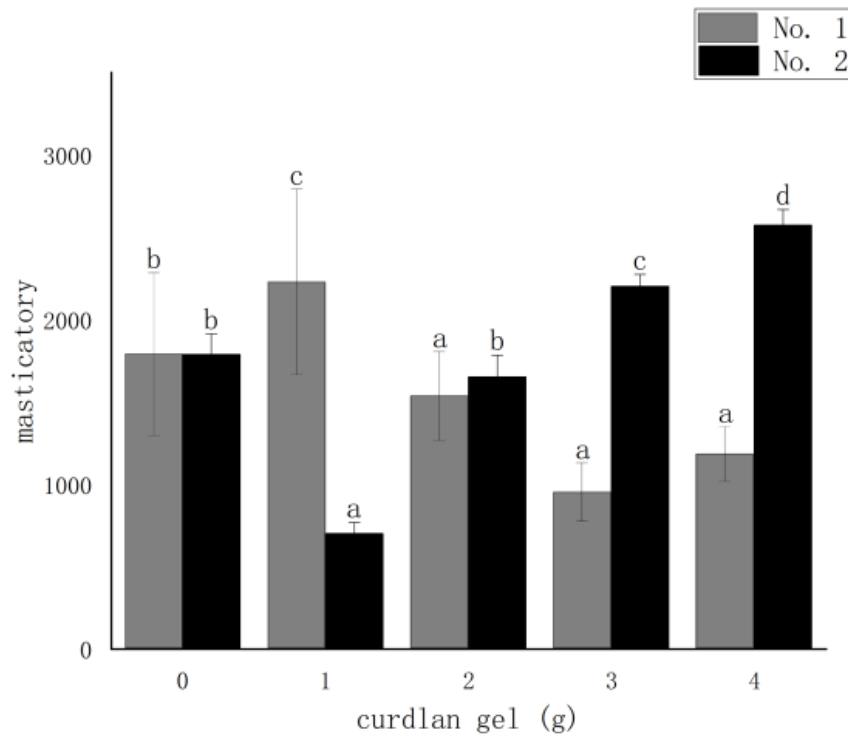
### 3.2.5. The effect of curdlan gel No.1 and No.2 on the viscosity of marinated beef



**Figure 8.** Influence of the amount of curdlan gel on viscosity

As can be seen from Fig.8, the viscosity of brined beef showed a tendency of increasing and then decreasing with the increase of the additive amount of curdlan gel No.1, reaching the peak at 1g additive amount and the lowest viscosity at 3g additive amount. Within 0-1g, the brined beef group as a whole showed higher viscosity, which was significantly ( $P < 0.05$ ) higher than the other three groups; while the viscosity was relatively lower at 2-4g of addition; the viscosity at 0g of addition was in between that of the 1g and 2g groups. The viscosity of brined beef showed a decreasing and then increasing trend with the increase of the added amount of curdlan gel gum No.2, reaching the peak at 3g, and the lowest viscosity at 1g. The above results show that the appropriate addition of curdlan gel gum No.1 will degrade and cross-link some proteins in marinated beef to form large insoluble molecules, resulting in the increase of viscosity [39]. However, excessive addition will affect the viscosity of marinated beef.

### 3.2.6. Differences in the effect of curdlan gel No.1 and No.2 on the chewiness of marinated beef



**Figure 9.** Influence of the amount of curdlan gel added on masticatory

As can be seen from Fig.9, with the increase of the addition of curdlan gel No.1, the chewiness of brined beef showed an overall decreasing trend compared with that of brined beef at 0g, and the chewiness of brined beef was significantly reduced under the conditions of 2g and 3g ( $P < 0.05$ ), and reached a peak at the addition of 1g, while the chewiness of brined beef was the lowest at the addition of 3g. The textural analysis showed that the chewability of brined beef was significantly reduced by the addition of curdlan gel No.1, which might be due to the change of the three-dimensional gel network structure and the enhancement of water absorption caused by the addition of cortisone [8]. On the contrary, curdlan gel gum No.2 significantly improved the chewiness of brisket with the addition of curdlan gel gum compared with that of the control group without the addition of curdlan gel ( $P < 0.05$ ), which indicated that curdlan gel could improve the quality of the products to a certain extent.

## 4. CONCLUSION AND OUTLOOK

In this study, beef tendon was used as raw material, and the quantitative brining process was utilised to determine the optimal brining process after pretreatment, brine injector injection of curdlan gel, marination, and brining, and then the effect of kojic acid gum on the textural properties of brined beef was determined. The effects of marinating time, brining time and simmering time on the organoleptic properties of corned beef were determined by one-way and orthogonal tests, and the optimal brining process parameters were finally obtained, and then the effects of curdlan gel gum No.1 and No.2 on the textural properties of corned beef were investigated on the basis of the optimal brining process, and the results were as follows:

(1) The optimum process conditions for brining beef were derived from the one-way and orthogonal tests as follows: marinating time of 6 hours, brining time of 40 minutes and simmering time of 20 minutes.

(2) The calculated content of the available curdlan gel gum No.1 is 71 per cent and the content of the available curdlan gel gum No.2 is 45 per cent.

(3) The textural properties of brined beef were determined by using the textural multifaceted profiling method with two kinds of curdlan gel, and the results showed that the overall trend was firstly upward and then downward with the increase of the added amount of curdlan gel gums, and the biggest effect on the textural properties of brined beef was achieved when the added amount of curdlan gel gums was 2%, which was the best effect. The results of the texture test showed that compared with the control group, the content of non-flammable water in the brined beef was significantly increased and the content of free water was decreased in the group with the addition of cortex 1, which resulted in a significant decrease in the hardness, stickiness and chewiness of the brined beef ( $P < 0.05$ ), while the changes of the elasticity, cohesiveness and repulsiveness were not significant ( $P > 0.05$ ). The structural changes of the three-dimensional gel network and the enhancement of water absorption caused by the addition of curdlan gel may be the intrinsic reasons for the reduction of hardness, viscosity and chewability of brined beef. Compared with the control group, the hardness of brined beef in the curdlan gel No.2-added group showed a tendency to increase, whereas the changes of viscosity, chewability, elasticity, cohesion and responsiveness were not significant ( $P > 0.05$ ). It was analysed and concluded that because the content of curdlan gel No.1 was higher than that of No.2, the effect on texture was also significantly higher than that of No.2, among which the effects on hardness, stickiness and chewiness were significant ( $P < 0.05$ ). Therefore, the addition of appropriate amount of curdlan gel during the processing of marinated meat products can effectively improve the quality of meat and prolong its shelf-life.

(4) Overall, the addition of 2% of curdlan gel could effectively improve the organoleptic quality of corned beef, whether it was curdlan gel No.1 or No.2, but the excessive addition of curdlan gel would cause gelatinous-like components to appear on the cut surface of corned beef, which would lead to the deterioration of the organoleptic quality of corned beef.

The test only explored the changes in the textural properties of brined beef by curdlan gel No.1 and No.2, but not the changes in the colour, flavour and microorganisms of brined beef by curdlan gel, which can be followed up to study the change rule of the edible quality of brined beef.

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