Forest Chemicals Review
www.forestchemicalsreview.com
ISSN: 1520-0191
May-June 2022 Page No. 417-430
Article History: Received: 24 February 2022, Revised: 05 April 2022, Accepted: 08 May 2022, Publication: 30 June 2022

Effect of Vacuum Tumbling on Salting Quality of Fresh Pork

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Abstract:

In addition to adding special flavor to meat products, salting can also extend the edible storage period, which is especially important for pork with huge annual output and consumption. To render better pork salting quality, this paper takes pork as the research object, investigates the effects of salting conditions such as salting time, temperature, salt content, etc. on the sensory quality and freshness of pork. It was found that, salting time, temperature and salt content exerted a great influence on the sensory quality, salting liquid absorption rate, pork tenderness and freshness. With the prolongation of salting time, pork had better sensory quality, higher tenderness and greater salting liquid absorption rate, while TVB-N value and TBA growth rate slowed down. With the increase of salting temperature, pork had gradually decreased sensory quality, but increasing salting liquid absorption rate, tenderness, TVB-N and TBA values. With the increasing salt content in salting liquid, the sensory quality first increased and then decreased, while meat tenderness, salting liquid absorption rate, and TVB-N value presented a decreasing trend. Experiments show that under certain conditions, vacuum tumbling and salting can better inhibit the activity of endogenous enzymes and microorganisms in pork during the salting process, hinder spoilage, effectively maintain the sensory quality and pork tenderness, and increase the salting effectiveness and quality.

Keywords*: Pork, Vacuum tumbling, Salting, Shear force, Freshness.*

I. INTRODUCTION

Rich in fat, protein and other nutrients, pork is one of the most important animal foods on the table. According to statistics, the annual global production of live pigs is about 1.03 billion, and the output of pork is about 100 million tons, while China's annual pork consumption exceeds the world's total annual pork production by 40%.

As one common meat processing method, salting can effectively prolong the pork storage period and change the original pork flavor and texture [1]. Traditional salting mainly includes dry salting, wet salting and mixed salting [2]. Nevertheless, with the gradual development in salted meat products and the continuous innovation of salting process, the traditional salting with slow salting speed, unstable quality and easy microbial contamination is gradually replaced by rapid salting means of vacuum salting,

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ultra-high pressure salting [3], tumbling salting, ultrasonic salting, pulsating vacuum salting. The appearance of rapid salting methods has greatly shortened the salting time of meat products and improved its edible quality. However, some rapid salting methods have too high costs to apply in batch salting of raw materials [4].

As one rapid salting method, vacuum tumbling salting is extensively studied and used due to its advantages of fast salting speed, low salting cost and product quality improvement effect [5,6]. Yan Hongbing [7] found that, compared with other salting processes, vacuum tumbling salting increases salting efficiency and improves the meat color, flavor, tenderness more significantly. Su Ting et al. found that, vacuum low-temperature tumbling salting can better inhibit the life activities of microorganisms and endogenous enzymes in salted grass carp products, with food safety and storability effectively improved [8]. Guo Yaotang studied the effect of tumbling time, vacuum degree and compound phosphate addition on beef tenderness, yield, texture, etc [9]. It was found that vacuum tumbling salting can significantly ($P<0.05$) improve beef tenderness, yield, and texture features to render better edible quality. Ding Yuting et al. found that vacuum tumbling salting can well improve the color, aroma and taste as well as mouthfeel of duck meat [10]. Liu Qiaoyu et al. mainly investigated the effect of vacuum tumbling conditions on the quality of white spiced beef, but failed to delve into the interaction between factors [11]. So far, the research on vacuum tumbling technology mostly focuses on tumbling time and vacuum degree, while temperature, salt content and specific application on pork are rarely studied.

Accordingly, this study took pork as raw material to analyze the effects of salt content, salting time and temperature on the sensory quality of pork, salting liquid absorption rate, shear force and salted pork freshness, which provides reliable theoretical and technical support for industrialized production of salted pork products.

II. MATERIALS AND METHODS

2.1 Experimental Materials and Instruments

2.1.1 Materials and reagents

Pork, provided by Bengbu Hongye Meat Processing Complex Limited.

Salt, trichloroacetic acid, disodium EDTA, thiobarbituric acid, magnesium oxide, boric acid, hydrochloric acid, methyl red indicator, bromocresol green indicator, 95% ethanol, 1,1,3, 3-Tetraethoxypropane were all domestic reagents of analytically pure grade.

2.1.2 Main instruments and equipment

Electronic balance, Shanghai Mettler Instrument Co., Ltd.; UV-Vis spectrophotometer, Shanghai Jinghua Technology Instrument Co., Ltd.; vacuum tumbler, Shanghao Technology Co., Ltd.; Kjeldahl

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apparatus, Hangzhou Lvbo Instrument Co., Ltd.; constant temperature oscillator, Changzhou Tian Rui Instrument Co., Ltd.; texture analyzer, Shanghai Baosheng Technology Instrument Co., Ltd.

2.2 Methods

2.2.1 Sample preparation

Wash the fresh streaky pork, cut it into 10cm*5cm*2.5cm, about 200g per piece, add salt water with different concentrations at 30% of the pork mass, put it under 0.06MPa vacuum, and tumble it for different time under different temperatures. After salting, the samples were evaluated for sensory quality, with 3 replicates per treatment.

(1)Effect of salting time on pork quality: the tumbling conditions were controlled as follows: 10% salt added, salting temperature 24℃, and salting time for 1.5, 2, 2.5, 3, 3.5, 4, and 4.5 h, respectively.

(2) Effect of salt concentration on pork quality: the tumbling conditions were controlled as follows: salting time 3h, salting temperature 24 ℃, salt concentration at 6%, 8%, 10%, 12%, 14%, 16%, 18%, respectively.

(3) Effect of salting temperature on pork quality: the tumbling conditions were controlled as follows: salt addition 10%, salting time 4 h, and salting temperature at 4, 8, 12, 16, 20, 24, 28 ℃, respectively.

2.2.2 Sensory evaluation

Sensory evaluation was performed on the salted meat. 10 professionally trained food professionals were selected to form a scoring group for sensory evaluation. The sensory evaluation indicators mainly include tissue structure, color and odor. The overall sensory score of the sample is the total sensory scores of tissue state, color and odor, with the sensory evaluation indicators and scoring criteria shown in Table I.

TABLE I. Sensory evaluation indicators and scoring criteria of pork after pickling

SENSORY INDICATOR	SCORING CRITERIA			
	16-20points	**10-15points**	**6-11points**	**1-5points**
COLOR	Normal color,uniform color,quite glossy	slightly dull color,relatively uniform color,glossy	Slightly dull color,relatively uniform color, lusterless	Dull color, uneven color,lusterless
ODOR	with normal odor of salted pork and distinct aroma	with normal odor of salted pork and light aroma	Mild aroma, with little unpleasant odor	With stench or rancidity

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TISSUE MORPHOLOGY	Tight tissue, clear texture	relatively tight tissue, relatively clear texture	Loose tissue, relatively clear texture	Loose texture
VISCOSITY	Slightly moist on the outside,no oil,not sticky	Wet on the outside,shiny,not sticky	Wet on the outside,less oily,slightly sticky	Wet on the outside,rich in oil, sticky
Elasticity	After acupressure,the depression recovers immediately,showing good firmness and elasticity.	After acupressure,the depression recovers relatively quickly,showing relative elasticity.	After acupressure, the depression recovers slowly, showing slight elasticity.	After acupressure,the depression cannot recover,showing no elasticity.

2.2.5 Absorption rate of salting liquid

Weigh the meat mass before salting (m1). After salting, use absorbent paper to absorb the moisture on the meat surface, and weigh it (m2). Calculate the salting absorption rate as follows:

$$\text{RMA（\%）} = \frac{m_2 - m_1}{m_1} \times 100\% \quad (1)$$

2.2.6 Determination of shear force

The shear force was measured with reference to "Shear Force Procedures for Meat Tenderness Measurement/T1180-2006". The salted meat was placed in a water bath at 90° C and heated to a core temperature 70° C, taken out and cooled, and allowed to stand at 4° C for 24 h. Samples were taken with a sampler along the parallel direction of the muscle fibers, and the shear force was measured. During the measurement, the myofibril was perpendicular to the cutter head, the shear speed was 1 mm/s, and the shear distance was 30 mm.

2.2.7 Determination of thiobarbituric acid (TBA) value

TBA value was measured with reference to the spectrophotometric method in GB 5009.181-2016 "Determination of Malondialdehyde in Food of National Food Safety Standard".

2.2.8 Determination of total volatile basic nitrogen (TVB-N) value

TVB-N value was measured with reference to the micro-diffusion method in GB 5009.228-2016 "Determination of Total Volatile Basic Nitrogen in Food of National Food Safety Standard".

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2.2.9 Data processing

In each group of experiments, data was measured three times in parallel, and the results were expressed in the form of "mean ± standard deviation". The experimental results were statistically analyzed using SPSS (IBM SPSS Statistics 25), with significant differences at $P < 0.05$.

III. RESULTS AND ANALYSIS

3.1 Effect of Salting Time on the Quality and Freshness of Salted Pork

Tumbling and salting time greatly affects the sensory evaluation and freshness of pork. In this experiment, the sensory quality and freshness of the salted pork was used as the main indicator to study the effect of tumbling and salting time, with test results shown in the Fig 1-4.

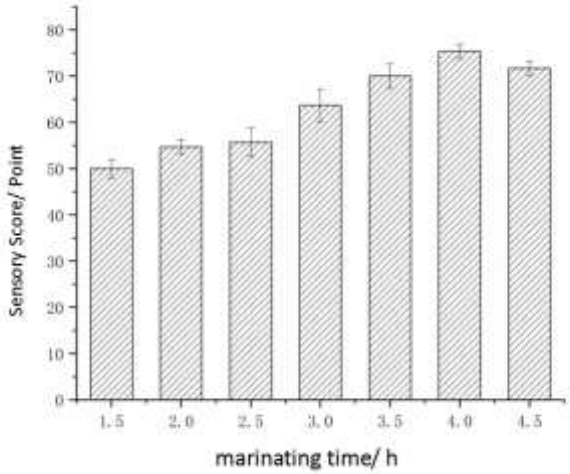

Fig 1: Effect of salting time on sensory score of pork

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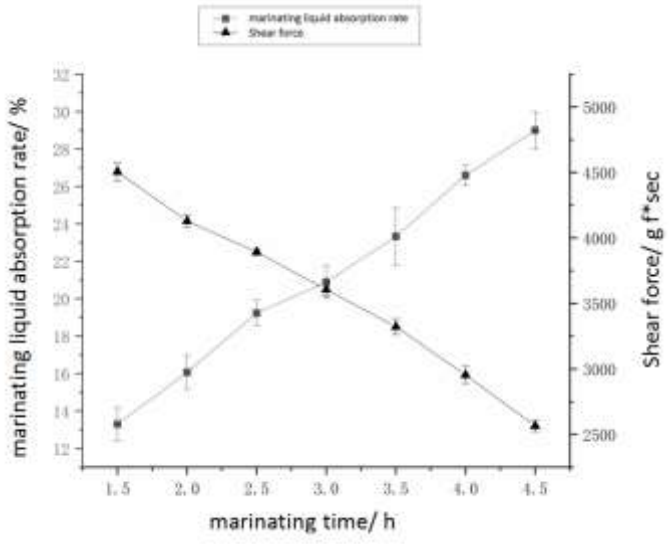

Fig 2: Effect of salting time on absorption rate and shear force of the curing liquid of pork

Shear force means the force required for a knife with certain dullness to cut meat of certain thickness. It can be used to judge the meat tenderness. The smaller the shear force value, the greater the meat tenderness, and vice versa [12]. Figu 1 and 2 illustrate the effects of salting time on the sensory quality, salting liquid absorption rate and shear force of fresh pork, respectively. Tumbling and salting time greatly affects the sensory score of pork, the salting liquid absorption rate and the shear force. With the prolongation of tumbling time, the sensory score of salted pork increased first and then decreased. It is possible that long-time tumbling and increased salting liquid absorption rate reduce the pork elasticity, resulting in a lower sensory score of the pork. The pork shear force decreased with the increase of salting time, indicating that longer tumbling time will improve pork tenderness accordingly. It is possible that, during the tumbling and salting, meat pieces are constantly tumbled, collided, and beaten. The physical force generated in these series of movements further increases the gap between muscle tissues and reduces the binding force between tissues, so that myofibril has weakened strength or even breaks, which in turn reduces the meat shear force, increases the salting liquid filtration, enhances the muscle tenderness and increases the salting liquid absorption rate [13]. The tumbling destroys the muscle tissue structure, helps tenderizing enzymes release and function in the tissue, thereby increasing tenderness [14]. In addition, loosening of muscle tissue allows more salt to infiltrate into the muscle, which increases the dissolution of salt-soluble muscle protein, also resulting in greater meat tenderness.

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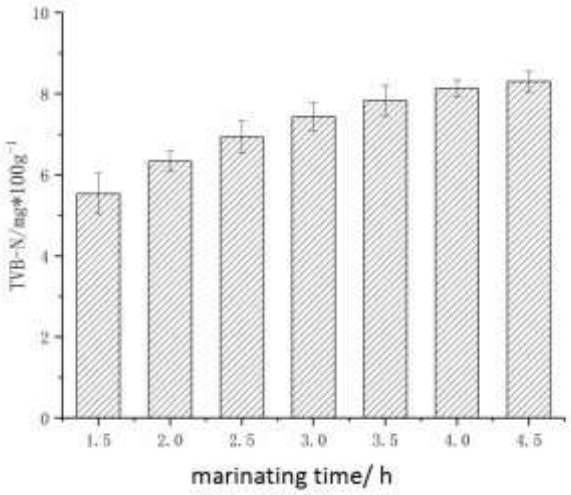

Fig 3: Effect of salting time on TVB－N value of pork

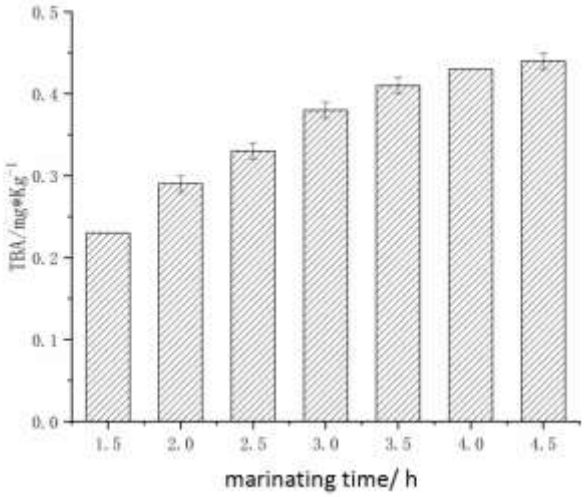

Fig 4: Effect of salting time on TBA value of pork

Total volatile basic nitrogen (TVB-N) is ammonia and amine alkaline nitrogen-containing substances produced by proteins in meat products under the action of enzymes and bacteria. Having high relevance with sensory quality, it is widely used to measure the freshness of meat products, which is also the only indicator for meat freshness evaluation in the current national standard [15-17]. Fig. 3 shows the changes in TVB-N value of fresh meat under different salting time. With the prolongation of salting time, the total TVB-N value of salted meat presents an increasing trend, but with increasing rate decreased from 14.46% to 3.01%, indicating that during the salting, the muscle protein is continuously decomposed into ammonia and amine alkaline nitrogen-containing substances. With the increase of salting time and infiltration of salting liquid, TVB-N value growth rate slows down. It is possible that salting liquid can inhibit the activity of deaminase, degummase and other biological enzymes in meat products, reduce the production

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of ammonia and amine alkaline nitrogen-containing substances, slow down the hydrolysis of protein, thus maintaining freshness.

TBA is an important indicator to evaluate the degree of oxidative rancidity of meat fat. A higher TBA value indicates higher degree of fat oxidation, greater impact on the sensory acceptability of the product, such as color, odor, and water holding capacity, and therefore worse quality. It is generally believed that when TBA>0.5 mg MAD/kg, fat begins oxidization, and when TBA>3.0 mg MAD/kg, meat products are spoiled [18]. Fig. 4 shows that with the increase of salting time, the TBA value of pork displays an increasing trend, but with gradually decreased growth rate, reaching the lowest level at 4.5 h. It is possible that with the prolongation of salting time, the infiltration of salting liquid inhibits the enzyme activity in the pork, thereby lowering the fat oxidation rate. It can be seen that, by increasing the salting time, it is possible to inhibit the activity of endogenous enzymes and microorganisms in pork, slow down the hydrolysis and oxidation rate of protein and fat, thereby maintaining pork freshness.

3.2 Effect of Salting Temperature on the Quality and Freshness of Salted Pork

The effects of salting temperature on the quality and freshness of fresh pork during salting are illustrated in Fig 5-8.

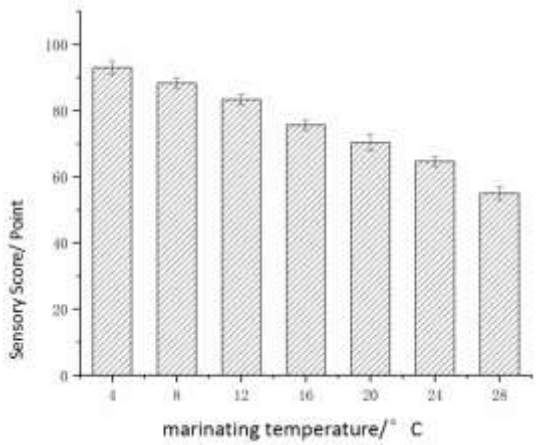

Fig 5: Effect of pickling temperature on sensory score value of pork

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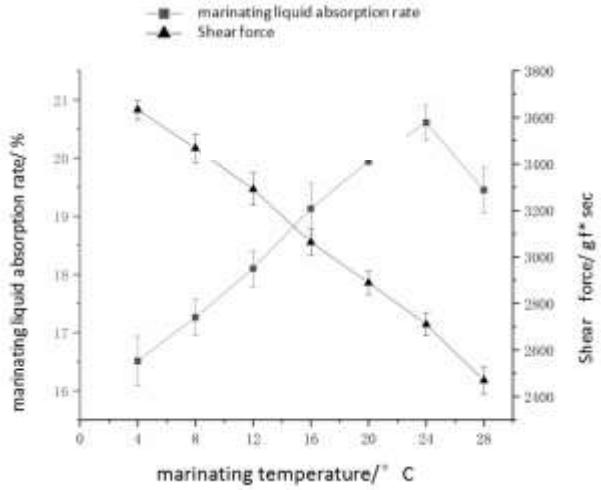

Fig 6: Effect of pickling temperature on absorption rate and shear force of the curing liquid of pork

Temperature is an important factor affecting food spoilage. With the increase of temperature, the oxidative decomposition rate of food and the life activities of microorganisms are enhanced to varying degrees. Fig. 5 shows the sensory scores of salted pork at different temperatures. As salting temperature rises, the intensified oxidation degree and microbial life activities adversely affect the pork color, stickiness, odor, elasticity, resulting in continuously decreased overall sensory acceptability. Fig. 6 shows the effect of salting temperature on pork tenderness and salting liquid absorption rate. The shear force value reaches the maximum at 4 ℃, indicating poor muscle tenderness at this time when salting liquid absorption rate is also at the lowest level of 16.51%. It is possible that the muscle tissue is more compact with slow molecular movement under low temperature, resulting in low salting liquid absorption rate and high shear force. In a low tem| marinating temperature/° C al enzymes have greatly lower activity, various hydrolysis reactions and oxidation reactions have greatly reduced rate, rendering better pork quality. As salting temperature rises, salting liquid has greater absorption rate, reaching the maximum value at 24 ℃; muscle tissues have gradually expanding gap, muscle fibers have weakened strength, with shear force decreased and tenderness increased. Under higher salting temperature, the salted meat has greater tenderness, but decreased salting liquid absorption rate. It is possible that water retention of the pork decreases under higher temperature.

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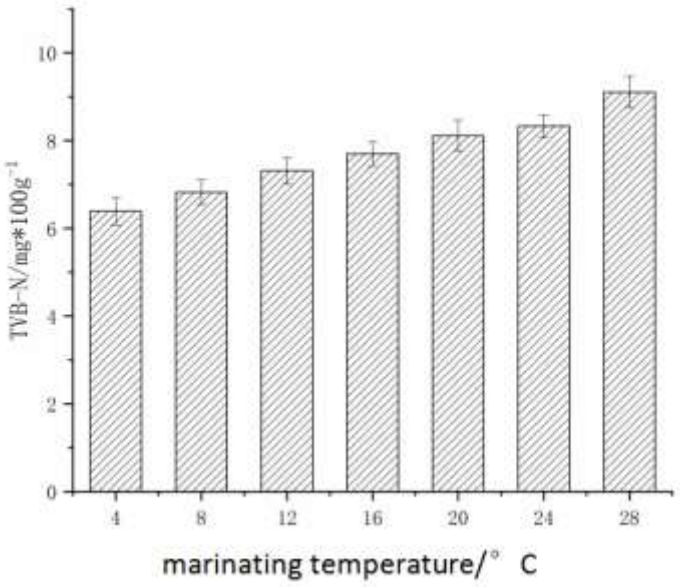

Fig 7: Effect of pickling temperature on TVB—N value of pork

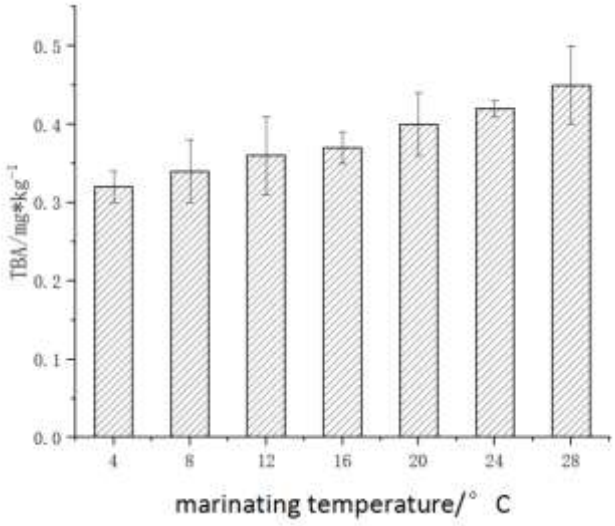

Fig 8: Effect of pickling temperature on TBA value of pork

The effect of salting temperature on pork freshness is illustrated in Figures 7 and 8. With the increase of temperature, both TVB-N value and TBA value present an increasing trend, reaching the maximum at 28℃. The increase of temperature boosts various microbial life activities in the muscle, increases the endogenous enzyme activity of the muscle, and accelerates protein hydrolysis and fat oxidation. In addition, the increase of temperature enlarges the gap between muscle tissues. Increased muscle moisture content also facilitates the reaction, which in turn increases TVB-N value and TBA value, lowering freshness. Hence, it is best to control the salting temperature at 4℃.

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3.3 Effect of Salt Content on the Quality and Freshness of Salted Pork

The effect of liquid salt content on the quality and freshness of fresh pork during salting is illustrated in Fig 9-12.

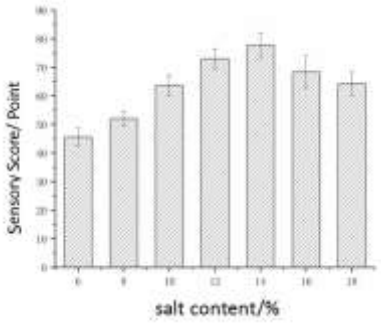

Fig 9: Effect of preserved liquid salt content on sensory score value of pork

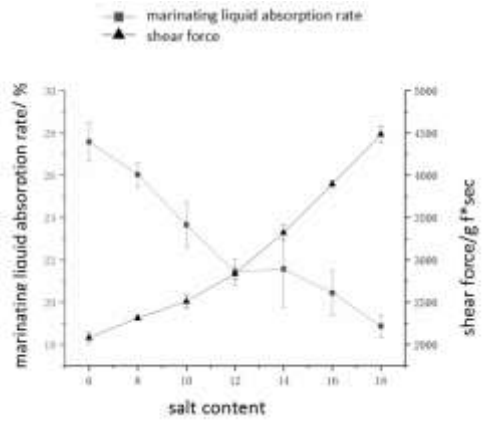

Fig 10: Effect of preserved liquid salt content on absorption rate and shear force of the curing liquid of pork

Salt (NaCl), one important component of food (especially meat products), has relation with the oxidation process of protein and lipid. In the processing of meat products, addition of salt will affect the secondary structure of protein and the emulsification effect of fat, as well as the physical and chemical properties of protein and lipid in the product, which in turn affects indicators such as product texture, sensory quality, and yield [19,20]. Fig. 9 illustrates the effect of salt content on the sensory quality of salted pork, and Fig. 10 shows the effect of salt content on the salting liquid absorption rate and shear force of salted pork. Under low NaCl content, salted meat has low emulsification degree, white color, loose muscle tissue and low sensory score. With the increase of NaCl content in salting liquid, myosin and actin in meat have increased dissolution, resulting in increased pork compactness and elasticity, with color turning rosy, so the sensory score is higher. After the NaCl content in the salting liquid exceeds 14%, if the NaCl

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content is further increased, the sensory score begins to decrease, possibly because the high NaCl content denatures and aggregates the protein, with meat hardness gradually increased and elasticity decreased, making meat color gradually changing from bright to dark red. As the NaCl content in the salting liquid increases, water in the pork is gradually dissolved out, with salting liquid absorption rate decreased. For its reason, pork tissue has big internal and external osmotic pressure, water is needed for osmotic pressure balance. In addition, with the increase of salt content in the salting liquid, the density and hardness of the muscle tissue increase, which is also the main reason for the continuously increased pork shear force and the decreased tenderness.

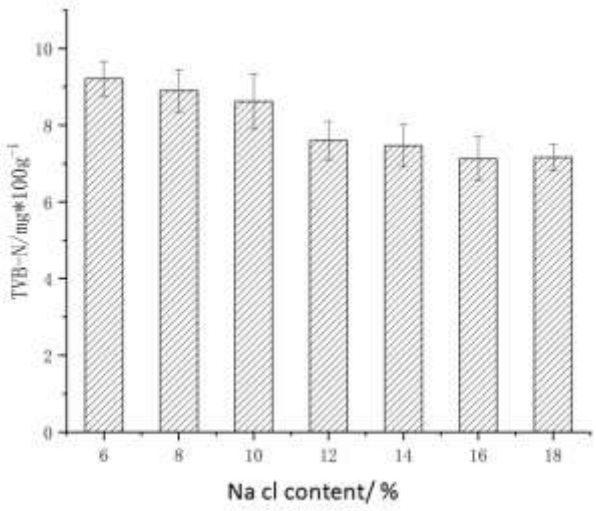

Fig 11: Effect of preserved liquid salt content on TVB-N value of pork

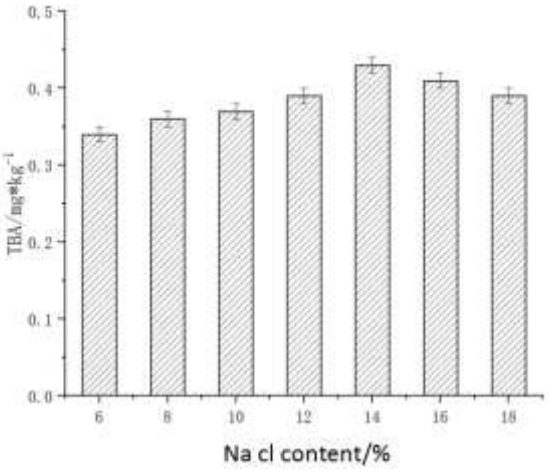

Fig 12: Effect of preserved liquid salt content on TBA value of pork

Fig 11 illustrates the effect of liquid salt content on the total volatile basic nitrogen (TVB-N value) of

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pork. The increase of salt content is accompanied with the decrease of TVB-N value. The increase of NaCl content makes the external osmotic pressure gradually increase and water content in the muscle tissue gradually decrease, which is inconducive to the occurrence of chemical reactions. On the other hand, higher concentration of salt water inhibits life activities of endogenous enzymes and microorganisms in pork, resulting in decreased ability to generate volatile nitrogen-containing substances, which in turn reduces the TVB-N value of pork. Fig. 12 illustrates the effect of liquid salt content on the TBA value of pork. On the whole, the addition of NaCl contributes to fat oxidation. In particular, under low concentrations, the TBA value of salted meat increases with the increase of NaCl content, reaching the maximum when the NaCl content was 14%. If NaCl content is further increased, the TBA value begins to decrease. For its reason, high salt inhibits the dissolution of oxygen and reduces the content of reactive oxygen species that facilitate fat oxidation in meat, which in turn slows down fat oxidation [21]. In addition, lipid oxidation can negatively affect the color, water retention, and sensory acceptability of meat products, thereby reducing sensory scores.

IV. CONCLUSION

Vacuum tumbling and salting can increase the pork salting efficiency and improve the salting quality. Different salting conditions mean different effects on the sensory characteristics, freshness and quality of salted products. The study found that sensory score of salted pork fluctuates greatly under different salting conditions. Pork tenderness and salting liquid absorption rate increased with the increase of salting time and temperature, but decreased with the increase of salt concentration. By appropriately prolonging the salting time, reducing the salting environment temperature, and increasing the liquid salt concentration, it is possible to effectively preserve the pork freshness and inhibit spoilage. Vacuum and low-temperature tumbling and salting can better inhibit the activity of microorganisms and endogenous enzymes in salted pork products, inhibit fat oxidation and generation of ammonia and amine alkaline nitrogen-containing substances, thereby effectively preserving the freshness of meat products, increasing the safety and storage life of salted meat.

ACKNOWLEDGEMENTS

This research was supported by Anhui Provincial Major Science and Technology Project (201903a06020010), Anhui Provincial Key Research and Development Project (20164a0702031, 201904a06020028), Anhui Provincial Joint Research Project of Science and Technology Innovation in Yangtze River Delta (202004g01020009), Provincial Natural Science Research Project of Anhui Colleges (KJ2021A1120), Industry-University-Research cooperation projects "Key Meat Processing Technology Research and Equipment Development", "Research and Development of Natural Preservative Technology for New Low-fat Canned Meat".

REFERENCES

[1] Desmond E. Reducing salt:A challenge for the meat industry. Meat Science 2006, 74(1):188-196.
[2] Zhou G H. Meat Processing. Beijing: China Agricultural Press, 2009.

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[3] Kruk Z A, Yun H, Rutley D L, et al. The effect of high pressure on microbial population, meat quality and sensory characteristics of chicken breast fillet. Food Control, 2011, 22(1):6-12.
[4] Wang L, Zhan K, Zhou S Z. Effects of different salting methods on the eating quality of pork. Food Science and Technology, 2021, 46(04):96-102.
[5] Schulze B, Peth S Hijbbermann E M, et al. The influence of vacuum impregnation on the fortification apple parenchyma with quercetin derivatives in combination with pore structures X-ray analysis. Journal of Food Engineering, 2012, 109(3):380-387.
[6] Beate S, Stephan P, Eva M H, et al. The influence of vacuum impregnation on the fortitication apple parenchyma with quercetin derivatives in combination with pore structures X-ray analysis. Journal of Food Engineering, 2012, 109(3):380-387.
[7] Yan H B. Comparison of seasoned duck marinating effects under different tumbling and marinating processes. Bulletin of Fermentation Science and Technology, 2021, 50(02): 70-74+81.
[8] Su T, Wang H, An J C, Guo Z, Mao C C, Guo D B. Effects of vacuum tumbling and salting on the quality of grass carp. Meat Industry, 2021(03):41-45.
[9] Guo Y T, Wang M F, Luo Y C, et al. Effect of tumbling process on beef quality. Science and Technology of Food Industry, 2020, 41(08):177-182.
[10] Ding Y T, Hu H, Lv F, et al. Effect of tumbling and marinating methods on the marinating quality of duck meat. Food and Fermentation Industries, 2013, 39(2):200-204.
[11] Liu Q Y, Bai W D, Huang M, et al. Effects of beef vacuum tumbling conditions on the quality and yield of white braised beef. Food and Fermentation Industries. 2013, 39(2): 205-212.
[12] Wang X Y, Zhou G H, Xu X L, Li C B. Determination of Pork Shear Force. Food Science, 2012, 33(21): 64-67.
[13] Wang Z M, He Z F, Li H J, Yu L, Huang H, Wang S, Xu M Y. Effects of vacuum tumbling and marinating on the quality characteristics of IRA rabbit meat. Food Science, 2015, 36(17): 54-58.
[14] Li C, Wang D Y, Xu W M, et al. Effect of final cooked temperature on tenderness, protein solubility and microstructure of duck breast muscle. LWT-Food Science and Technology, 2013, 51(1):266-274.
[15] Yang H S. Effect of radix puerariae extracta on pysicocemical and sensory quality of precooked pork sausage during cold storage. LWT-food Science and Technology, 2012, 46(2):556-562.
[16] Yang W G, Xue C H, Xu D L. et al. Changes of ATP-related compounds contents and freshness evaluation of Pseudosciaena crocea meat during iced storage. Transactions of the Chinese Society of Agricultural Engineering, 2007, 23(6):217-122.
[17] Wang T J, Wang Y J, Zou W. Study on the differences between value of TVB-N and sensory index of pork. Science and Technology of Food Industry, 2007, 28(12):124-126.
[18] Yanar Y, Fenercioglu H. The utiization of carp (Cyprimu scarpio) flesh as fish ball. Turkish Journal of Veterinary and Animal Science, 1998, 23:361-365.
[19] Li K, Zhao Y Y, Kang Z L, et al. Effects of NaCI on the processing properties and protein secondary structure of minced pork. Food Science, 2017(15):89-93.
[20] Wang Z G, Yan L P, Peng Z Q, et al. Effect of NaCl concentrations and pH on amount of protein adsorbed by fat particles and its emulsion gel property. Science and Technology of Food Industry, 2011, 32(10)190-13
[21] Qu C, He Z F, Wang Z M, et al. Effects of Different Salt Concentrations on Lipid Oxidation, Protein Oxidation and Eating Quality of Cured Chicken Meat. Food Science, 2020, 41(16):77-85.