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ANALYSIS OF THE CORRELATION BETWEEN THE FRESHNESS INDICES OF PORK AND ITS PORK EXUDATE

– Short communication –

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Abstract: In recent years, as the Chinese consumption level increased, the consumption quantity of fresh pork had been increasing year by year. Freshness was an important index to judge the quality of pork. This study aimed to analyze freshness indices change of pork and pork exudate during storage. Thus the conclusion of this study was to characterize freshness change of pork by change law of freshness indices of pork exudate. So as to provide a reference for more convenient determination of the pork freshness. The results showed that the freshness indices of pork and their exudates change accordingly with the increase of storage time. On day 3, the pork seeped out more obvious juice. The turbidity of pork and its exudates increased gradually with the decrease of freshness, and sensory scores decreased gradually. The color changed from bright red to reddish brown and finally grey brown. The indicators of pork and their exudates (the total volatile basic nitrogen, the pH, a* and turbidity levels) were significantly correlated at the 0.01 level, the correlation coefficients were 0.9727, 0.9823, 0.9205, and 0.8765, respectively. Therefore, freshness indices of pork exudates can reflect the freshness of pork.

Key words: pork; pork exudate; freshness index; freshness and drip loss

INTRODUCTION

Pork freshness is a comprehensive evaluation of the flavor, color, texture, taste, microbes and hygiene standards (Chang et al, 2014), which is used to reflect nutrition and safety of meat products (Bin, 2007). Main quality evaluation indices include organoleptic characteristics, microbiological content, decomposition product content and properties of pork, etc (Vinci & Antonelli , 2002; Yao et al., 2011; Mancini & Hunt, 2005; Kress et al, 1993; Malakar et al., 2003; Sanjay et al., 2008). At present, sensory detection (Yu-Wen et al., 2018; Shi et al, 2018; Nam et al, 2009), physical and chemical tests (Wang et al., 2007; Liang et al., 2017; Yao-Hua et al., 2012; Cheng et al., 2010) and microbiological tests (Shi et al., 2011; Niu et al., 2011; Wang et al., 2007) of meat products were used to judge the freshness of pork. Among them, the total volatile base nitrogen (TVB-N), a national standard, is used to determinate pork freshness. The total volatile base nitrogen (TVB-N) had significant difference under different freshness, which according to this standard, meat is divided into three grades, including fresh meat (TVB-N < 15 mg/100 g), sub-fresh meat (15 ≤ TVB-N ≤ 25mg/100 g) and corrupted meat (TVB-N > 25mg/100 g). (Huang & Liu, 2010). The water holding capacity referred to the ability of pork to retain water in tissues as well as an important index for meat quality traits, which not only affected the nutritional quality, succulentness, texture of meat, but also had economic value. Currently, main moisture determination methods of meat and meat product include the drip loss rate, the pressure loss rate and the cooking loss rate, which are used to determine the water holding capacity of meat and meat products (Liao, 2010).

In this paper, the drip loss rate, the total volatile basic nitrogen, pH, color, and turbidity of the pork exudates and pork were measured during the storage of pork, and linear regression and correlation analysis are carried out among the indicators. The aim of this study is to characterize freshness change of pork by change law of freshness indices of pork exudate. So as to provide a reference for more convenient determination of pork freshness.

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MATERIALS AND METHODS

Pork samples

The fresh pork were selected to be similar in color, shape, and texture, and position, which were purchased from Renrenle Supermarket of Tianjin Economic-Technological Development Area (Tianjin, China). Each sample was chopped into approximate dimensions of 4cm × 3 cm ×2 cm (length × width × thickness) cubes and trimmed as flat as possible. The pork samples were packed in sealed plastic bags individually and stored in the incubator of constant temperature and humidity (LRHS-500-II, Shanghai, China) at 5°C. Pork exudate which the juice from pork was sucked by pipette and placed in centrifugal tube. The relevant indicators of the pork samples and pork exudates samples were tested each day.

Indicator detection

(1) The drip loss rate determination (Xia et al., 2013): the drip loss rate was analyzed according to the method of Bertram et al. (2011)., by using the formula (1).

$$W\% = [(W_2)-(W_3)/(W_1)-(W_3)] \times 100\% \quad (1)$$

In the formula (1), W_1 was the total weight of tray, meat and meat exudate, W_2 was the total weight of the meat exudate and the tray, and W_3 was the weight of the tray.

(2) Transverse relaxation times determination (T2) (Xia et al., 2011; Chen & Xue, 2009) was measured with a NMR system(MicroMR-025, Niumag Electronics Technology Co, Ltd): A Bruker AVANCE III solid state NMR spectrometer (300 MHz for proton) was used to determine the samples transverse or spin–spin relaxation times, T2. The transverse relaxation time was obtained with a Carr–Prucell–Meiboom–Gill (CPMG) pulse sequence with a 90–180° pulse spacing of 200 μs and a repetition time of 1800ms.The magnetization was recorded after 2600 echos cnt, with the precaution that the number of echos always permitted to define an exponential decay for the magnetization. Samples were cut into 10g/ copy, 1.5 cm high, and placed in a 5 mm standard NMR tube, for the T2 measurement. It was clear that the relaxation time measurements were not spatial resolved, but subcellular water compartmentation can be monitored (Jiang et al., 2010).

(3) TVB-N determination: pork was first minced in a meat grinder TC22 (Guangdong Lewang Industrial Co., Ltd., China) for 50s. Ten grams of minced pork and 100 mL of water were put into a conical flask and mixed until homogeneous. After settling for 30 min, the supernatant from the conical flask was filtered. The filtrate and pork exudate were referenced to the determination of total volatile basic nitrogen in food in accordance with GB 5009.228-2016 National Standard for Food Safety about Automatic K-type nitrogen determination.

(4) pH determination (Zhang & Wang, 2012): The MP522 pH meter produced by Zhongyi Bai Control Instrument Co., Ltd. (Wuhan, China), which was used to measure the pH of the pork samples. Before the measurements, two standard buffer solutions of pH = 6.86 and pH = 4.00 were used to calibrate the pH meter, and the calibration temperature was 25 °C. The measurement was conducted immediately after the acquisition of the spectrum. Each sample was measured three times and the average value was recorded as the final pH.

(5) Instrumental colour determination (Vinci & Antonelli, 2002): A portable colorimeter (SP60, Xripe, London, America) was used to assess the parameter L* (brightness), a* (redness / greenness), and b* (yellowness/blueness) CIELab coordinates of the samples CIELab, pre-cut into 1cm thick slices.

(6) Turbidity determination: Firstly, the pork filtrate was subjected to spectral scanning to obtain the maximum absorption wavelength of the juice. The absorbance of the filtrate was measured every 24 h at this wavelength, and the turbidity change was analyzed.

(7)Sensory analysis: Panelists were provided with ten sequential samples, each containing three pieces (c.a. 15 g pork meat) from the same storage day. Panelists were asked to write the sample code of each rating sample on a blank ballot (these codes differed from the ones used in the ranking test) and then rate the sample using a 5-point hedonic scale (Gao et al., 2015). The tested attributes were: smell (pork flavor intensity, no off-flavor: 5, light pork flavor , no off-flavor: 4, no pork flavor, no off-flavor: 3, light off-flavor: 2, off-flavor intensity: 1); color and brightness (bright red and shiny: 5, slightly bright red and shiny: 4, dark red and dull: 3, brown and dull: 2, dark brown and dull: 1); apparent characteristics (high intensity, extremely tender, juicy: 5, intensity, tender, juicy : 4, light intensity, light tender, light juicy: 3, no intensity, light tough, dry: 2, extremely tough, no intensity, dry: 1).

Data analysis

Data (means ±standard deviation) of TVB-N contents, pH, the drip loss rate, turbidity, sensory scores and a* value were statistically processed using SPSS (Yao et al., 2011).

RESULTS AND DICUSSIONS

Analysis of drip loss rate

As can been seen in Figure 1, the drip loss rate of the three groups increased gradually. However, the increasing trends of drip loss rate were little obvious within the first three days. After the 3th day, the rate of protein decomposition accelerated. The increasing trends of drip loss rate were obvious on days 6-8, and tended to balance from the 7th day. This could be explained with the formation of more free amino acids, peptides, peptones, etc. which the growth and reproduction of microorganisms and cell destruction was accelerating.

Distributions of T2 relaxation times for pork samples during 10 days of storage at 5℃

Spin–spin relaxation time (T2) of the samples was obtained with the purpose of evaluating water molecules dynamics and environment during storage. The CPMG data were analyzed as a continuous distribution of exponential relaxation times (Bertram et al., 2001). There were three T2 intervals in pork: T21 (0-10 ms), T22 (10-100 ms), and T23 (100-1000 ms). Among them, T21 represented water molecular layer which the polar groups on the surface of protein molecules bind closely to water molecules. T22 represented the water existing between myofibrils and membranes, and T23 represented the free flowing water existing in the extracellular space. Figure 2 shows the T2 inversion diagram of the transverse relaxation time of pork. In the early storage period, the integral area of T22 and T23 accounted for 96.19% and 0.14% of the total integral area.

On day 10, the integral area of T22 accounted for 94.43% of the total integral area, decreased by 1.76% compared with the initial storage period, and the integral area of T23 accounted for 0.48% of the total integral area, increased by 0.34% compared with the initial storage period. This showed that the immobile water between myofibrils and the membrane migrated to the free water, which caused the drip loss rate of pork increased continuously.

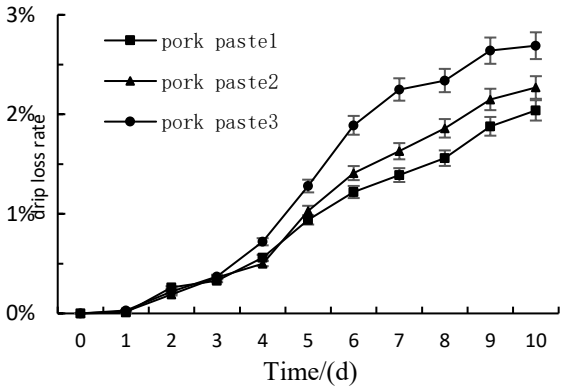

Figure 1. Analysis of drip loss rate

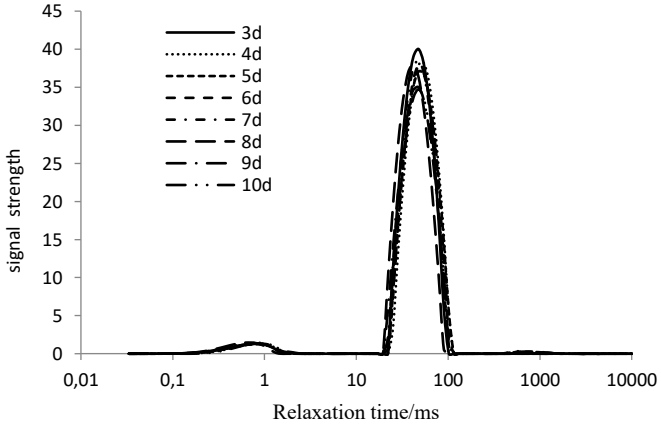

Figure 2. Changes of pork relaxation time T2

The total volatile basic nitrogen change of pork and pork exudate

Due to microbial spoilage and biochemical reactions, proteins produced alkaline toxic substances like ammonia (NH3) and amines (R-NH2), etc. Among these basic nitrogenous compounds constituted the total volatile basic nitrogen, which is an essential reference index for evaluating pork freshness (Davidek & Khan, 2010). According to National Standard of the People's Republic of China GB 2707-2016 (Hygienic standard for fresh (frozen) meat of livestock), the total volatile basic nitrogen content of fresh meat should be less than or equal to 15 mg/100g. From figure 3 can be seen, the total volatile basic nitrogen of pork and pork exudate increased significantly with the prolongation of storage time, but the total volatile basic nitrogen values of samples were below 15 mg/100 g within the first three days which indicated samples were fresh. On day 8, the total volatile basic nitrogen of pork exudate

had exceeded the standard reaching 17.12mg/100g, while the total volatile basic nitrogen of pork reached 15.36mg/100g on day 10. This could be explained with the deterioration of cell tissue and dissolution of intracellular fluid, which more total volatile basic nitrogen-containing substances were also brought in. Thus resulting in the total volatile basic nitrogen of pork exudate that was always higher than pork, which showed pork exudate can react pork freshness more accurately.

pH change of pork and pork exudate

With the prolongation of storage time, the surface of the pork began to multiply bacteria. The proteins of muscles were decomposed into toxic alkaline substances like ammonia and amines under the action of bacterial enzymes, which resulted in a significant increase with pH of pork (Khan et al., 2010).As can be observed in Figure 4, the pH of pork and pork exudate increased significantly with the prolongation of storage time. On day 8, the volatile base nitrogen of the pork exudate had exceeded the standard, and the corresponding pH was 6.44. When the total volatile basic nitrogen of the pork exceeded the standard, the corresponding pH was 6.68.

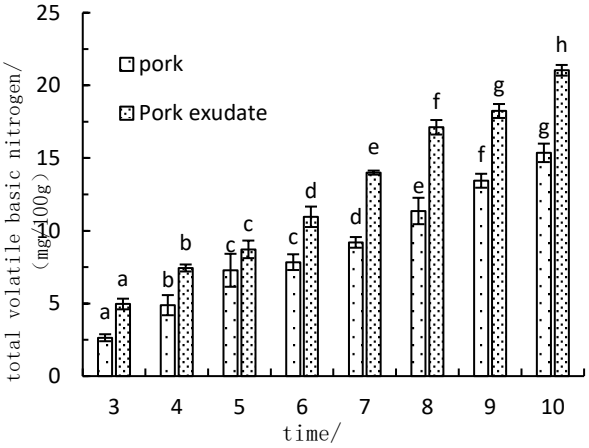

Figure 3. The total volatile basic nitrogen change of pork and pork exudate

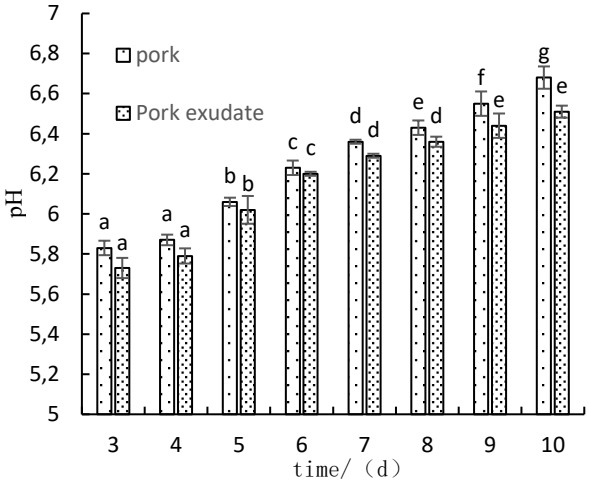

Figure 4. pH change of pork and pork exudate

Turbidity change of pork and pork exudate

According to spectral scanning of pork and pork exudate, it was found that the maximum absorption wavelength of pork filtrate and pork exudate was 620 nm, so the absorbance of pork filtrate and pork exudate was determined at 620 nm. As can be observed in Figure 5, the absorbance of pork filtrate and pork exudate gradually increased with the prolongation of storage time. The absorbance of the pork filtrate was less than the absorbance of the pork exudate, the reason of which may be that the pork exudate brought out a small amount of pork during the process of outflow, leading to a slightly higher turbidity, so its absorbance was higher than the pork.

Color changes in pork and pork exudate

The L*, a*, and b* values of pork had a certain amount of change with the prolongation of storage time. but the change of L* and b* value were not as significant as a* value, so the a* value was used to represent the freshness of the pork and pork exudates.

From Figure 6 can be seen, the a*values of pork and pork exudate decreased significantly with the prolongation of storage time, and the a*value of pork exudate had the largest change from 1 to 2.2.

Sensory evaluation of pork

Sensory scores of pork during 10 d-storage at 5°C are also presented in Figure 7. Sensory scores of samples gradually decreased during storage, which indicated pork freshness was declining. In the early period of storage, The sensory scores of pork samples were 5 (good quality) on day 2. The sensory scores of pork samples were 1 on day 10, which was below the acceptability limit (score of 5) in the sensory analysis. but the color change of pork was the most significant during storage, which showed change of pork color was more accurate than other sensory indicators to reflect pork freshness.

The correlation analysis is given in Table 1.

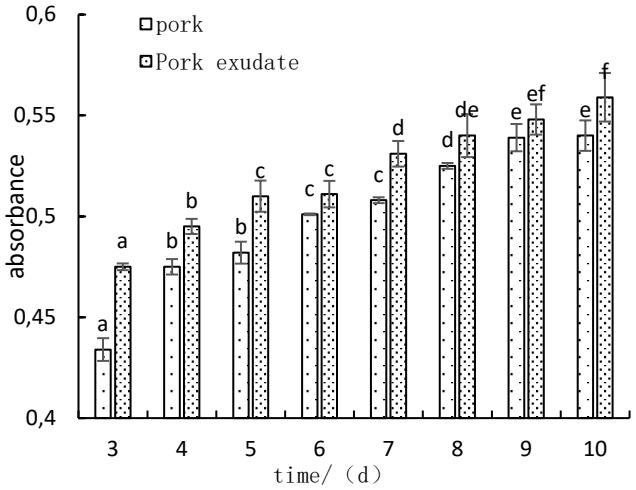

Figure 5. Turbidity change of pork and pork exudate

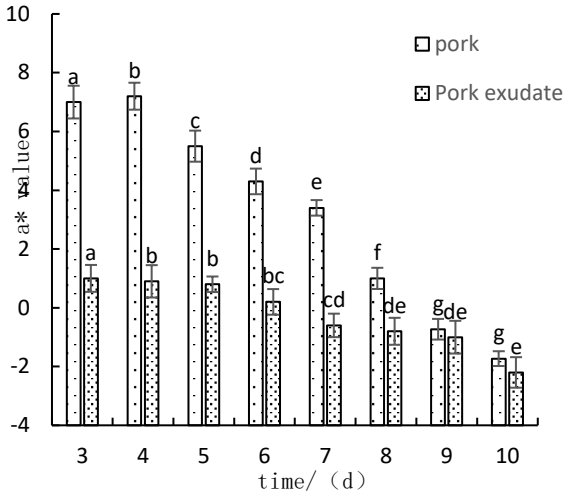

Figure 6. Changes of the color of pork and pork exudate

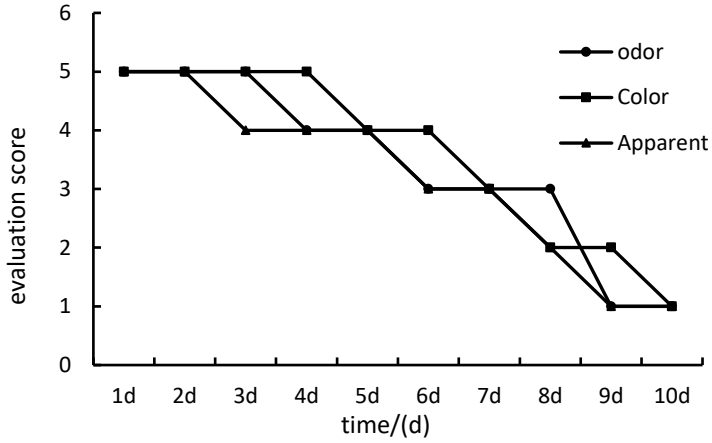

Figure 7. Pork sensory evaluation

Table1 The correlation analysis of indicators in pork and pork exudate

	Pork pH	Pork of TVB-N	Absorbance of pork	Pork a* value	Pork sensory value
Pork exudate pH	0.991**	0.962**	0.962**	-0.948**	0.923**
Pork exudate TVB-N	0.985**	0.986**	0.959**	-0.982**	0.895**
Pork exudate Absorbance	0.977**	0.987**	0.976**	-0.955**	0.977**
Pork exudate a*value	-0.963**	-0.950**	-0.887**	0.959**	0.912**

Note: * indicates significant difference (P<0.05); ** indicates extremely significant difference (P<0.01).

CONCLUSIONS

With the prolongation of storage time, the freshness of pork gradually decreased, and a large number of bacteria started to grow. Under the action of bacterial enzymes, the proteins of muscles were decomposed into toxic and alkaline substances such as ammonia and amines, and the cells were gradually destroyed. The results showed that drip loss rate, the total volatile basic nitrogen and pH of pork and pork exudate increased significantly with the prolongation of storage time. On day 3, the pork seeped out more obvious juice.The turbidity of pork and its exudates increased gradually with the decrease of freshness, and the score of sensory evaluation decreased gradually. The color changed from bright red to reddish brown and finally grey brown. It showed that the indexes of pork and pork

exudate had the same changing trend. The indicators of pork and their exudates (the total volatile basic nitrogen, the pH, color, and turbidity levels) were significantly correlated at the 0.01 level, the correlation coefficients were 0.9727, 0.9823, 0.9205, and 0.8765, respectively. Thus it was found that there was a strong correlation between the indexes of pork and pork exudate, which freshness indices of pork exudates can reflect the freshness of pork.

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