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Effects of Meat and Phosphate Level on Water-Holding Capacity and Texture of Emulsion-Type Sausage During Storage

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Abstract

This paper was designed to verify the influence of phosphate on water-holding capacity (WHC) and texture of emulsion-type sausage prepared with pre-rigor meat, ageing meat or frozen meat. Pre-rigor pork, ageing pork and frozen pork were pre-blended with five levels of phosphate and made into emulsion-type sausage. The yield, hardness and total expressible fluid (TEF) were measured with texture profile analysis machine and pressiometer when emulsion-type sausage was produced. Meanwhile, hardness and purge loss (PL) were measured during 30 d storage. As emusion-type sausage made by pre-rigor meat, higher yield and relatively stable hardness could be found. It indicated that increasing of phosphate level caused an alleviatable effects in increasing of hardness when emulsion-type sausage made by pre-rigor meat, but opposite effects made by ageing meat or frozen meat. The distribution of PL of emulsion-type sausage was found to be affected by phosphate addition. Significant decrease of PL could not be obtained by increasing of phosphate level during storage. Pre-rigor meat improved WHC and texture of emulsion-type sausage. Problem of WHC and texture of emulsion-type sausage during storage could not be resolved by single use of phosphate at relatively higher level (3%) of NaCl.

Key words: meat, emulsion-type sausage, water-holding capacity, texture

INTRODUCTION

Emulsion-type sausage is a kind of meat product that was made by the processing methods, such as comminuting and emulsification. The moderate denaturalization of meat protein during the thermal process gives the emulsion-type sausage fine texture and flavor which meet the consumer's requirement about nutrition and taste. However, during cooking and preservation, cooking loss (CL) and purge loss (PL) followed by adverse change of texture debase the quality of emulsion-type sausage.

There has been much research on the water-holding capacity (WHC) or texture, the two most important properties of emulsion-type sausage (Dai and Wu 2000; Andrés *et al.* 2006). However, little information has been done focused on their combined effects and WHC changes during preservation. A number of investigations, such as using non-meat protein or gel, increasing phosphates or controling spoilage bacteria, have been made on emulsion-type sausage with the respect to get fine WHC and texture (Colmenero *et al.* 2005; Ruusunen *et al.* 2003). Despite useful effect, those methods have their limitation. From a literature survey, it appears that none of the previous investigations is concerned with using pre-rigor meat in emulsion-type sausage processing in China.

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Pre-rigor meat has several potential economic advantages. Furthermore, maximum solubilizing of salt-souble protein in this meat contributes greatly to the production of emulsion-type sausage. There are optimistic prospects on the using of pre-rigor meat because the development of processing equipment and cold chain logistics in China. Meanwhile, concerning emulsion-type sausage prepared with pre-rigor meat, it has not been thoroughly investigated on the effect of phosphate on WHC and texture of sausage during storage. Previous study also showed that decrease of gel strength caused by limited hydrolyzation of heavy meromyosin (HMM) on meat ageing might reduce binding quality of the comminuted meat products (Yasui *et al*. 1982). Frozen meat for emulsion-type sausage production is extensively used in China. Although freezing meat has well property of transportation and preservation, frozen storage has a deleterious effect on the functionality of meat. Despite numerous phosohates product in meat additive market, information is needed to explain the effect of phosohates on WHC and texture of emulsion-type sausage during storage.

The main objective of this research is to investigate feasibility of using pre-rigor preblending to improve stroage quality of emusion-type sausage, and to explore effect of phosphate on WHC and texture of emulsion-type sausage.

MATERIALS AND METHODS

Formulation and sausage manufacturing

Emulsion-type sausage were developed using pork hindleg meat and pork tallow obtained from Sushi Co., Ltd. (Shanghai, China). The ratio of meat and tallow was 8:2. Pre-rigor meat was hot boned within 1 h postmortem. Ageing meat was conventinally boned after chilling at 0-4°C until 24 h postmotem. After stored at -18°C for 30 d, frozen meat was thawed with flowing water (20°C) for at least 6 h.

Meat was trimed off exterior fat and connective tissue and then was ground (1 cm plate). Ground meat were mixed with 3% NaCl, 0.05% sodium isoascorbate, 0.01% $NaNO_2$, and phosphate (0, 0.1, 0.2, 0.3, 0.4, and 0.5%, respectively). Finely mixed meat was salted 24 h at 0-4°C.

Mixed meat, 6% starch, 30% water, spices and tallow were in turn added during chopping. Ground ice was added in order to sustain the temperature of batter below 10°C. After chopping of 6 min, meat batter was filled in collagen reconstituted casing (diameter 2.5 cm) and hand-linked. Sausage were cooked in a temperature-controlled water-bath maintained at 80°C for 30 min. After natural cooled to room temperature, cooked sausage were packaged and stored at 0-4°C.

WHC

Yield (%) was measured by weighing the product before and after cooking, and weight ratio between after and before cooking corresponds to weight loss due to heating.

Total expressible fluid (TEF) of sausage was measured following the method of Carballo *et al*. (1995) and Peng *et al.* (2003). This parameter was measured on a pressiometer (WW-3 Nanjing, Jiangsu Province, China). For each treatment of 20 sausage cores (diameter 2.5 cm, height 1 cm) are held with a 69.44 N press for 10 min at room temperature. Results are expressed as percentage of fluid released.

PL was measured by removing packages of each type of sausage every 10 d during refrigerated storage. The sausages were taken out from the package, and carefully bloated with filter paper to eliminate any liquid on the surface of the links. The initial weight of the links had also been measured at the beginning of the experiment. PL was reported as a percentage between weight loss during storage and initial weight of sausage.

Texture analysis

Texture analyzer TA-XT2i (Stable Micro Systems, Godalming, U.K.) with a load cell of 5 kg was used to measure textural properties of sausage during the cold storage. The hardness were obtained from Texture Expert ver. 1.0 attached to the texture analyzer (Stable Micro Systems). For each treatment, 30 sausage cores (diameter 2.5 cm, height 1 cm) were compressed twice with 50% deformation with a stainless compression probe of 5 mm in diameter. Parameters for measurement were as follows: pretest speed, 2.0 mm s^{-1}; test speed, 0.5 mm s^{-1}; posttest speed, 5.0 mm s^{-1}; time between two compressions, 5.0 s; trigger type, auto-

20 g; and data acquisition rate, 200 point s^{-1}.

Microbial analysis

Total microbial number (lgCFU g^{-1}) was measured by pour plate method according to GB4789.2-1994 (China National Standards, CNS) every 10 d during refrigerated storage.

Sensory evaluation

Sensory evaluation of the cooked sausage was conducted by a taste panel of 10 trained experts who experienced in sensory evaluation of similar cooked sausages. Panelists were asked to indicate how much they like or dislike each product according to flavor, texture and overall acceptability characteristics (GB5009.44-1985, CNS).

Statistical analysis

Data were analyzed by one-way analysis of variance with Statistical Analysis System 6.12 for Windows (SAS Institute Inc., Cary, NC). Multiple comparisons of different treatments were performed by Duncan's multiple range test to determine significant differences between mean values of the different results.

RESULTS

Influence of phosphate on WHC of emulsion-type sausage

Yield is a practical index for determining water and fat loss during cooking of sausages. Mean values of process yield for three meat types and three phosphate treatments are shown in Fig.1. It ranged from 95.16 to 99.00% for the tested formulations indicating good thermal stability. The results showed that process yield could be affected by meat types and phosphates ($P<0.01$). Sausages made by pre-rigor meat had higher ($P<0.05$) process yield than those made by ageing meat or frozen meat. Process yield slightly increased when phosphate level more than 0.4% regardless of meat types.

Meat types and phosphates significantly ($P>0.05$) affected TEF of sausage (Fig.2). The sausage containing 0.4% phosphate had smallest TEF. It was essential of 0.2% phosphate to maintain lower TEF for ageing meat and freezing meat, but was 0.1% for pre-rigor meat. It means that 0.1% phosphate was the lowest degree for meat protein to form a gel matrix which immobilize both of fat and water when outside force was brought to sausage core.

Mean values for PL of emusion-type sausage for three meat types and six phosphate treatments are shown in Table 1. Adding phosphates could not significantly ($P>0.05$) affect PL at 10, 20 and 30 d during storage.

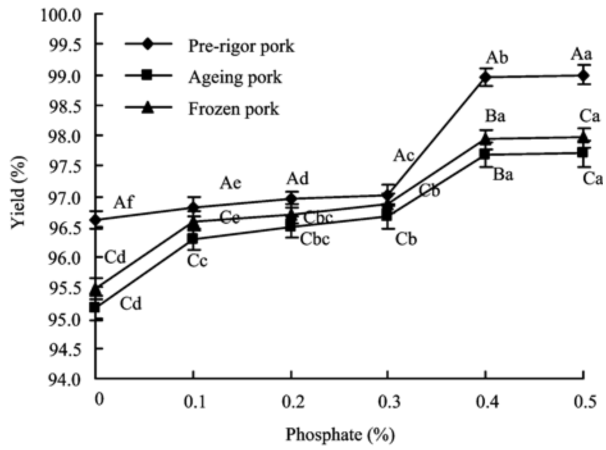

Fig. 1 Effects of meat and phosphate on yield of emulsion-type sausag. At same phosphate level, means without same capital sunerscrints differ significantly ($P<0.05$); at same meat state, means without same lowercase sunerscrints differ significantly ($P<0.05$). The same as in Fig.2.

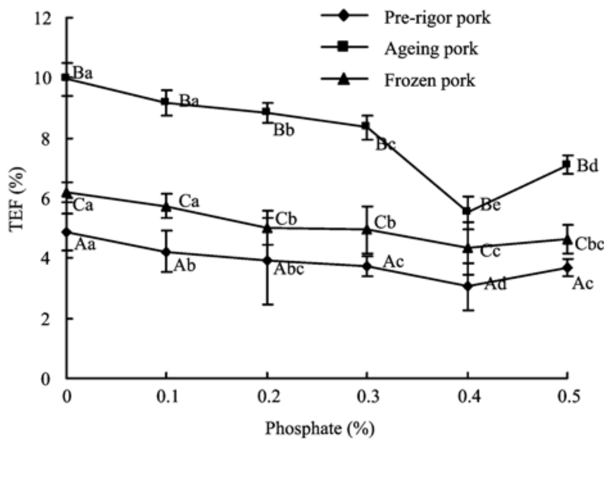

Fig. 2 Effects of meat and phosphate on TEF of emulsion-type sausage.

Table 1 Effects of meat, phosphate and storage on PL of emulsion-type sausage

Storage time (d)	Meat	Phosphate (%)					
		0	0.1	0.2	0.3	0.4	0.5
10	P	2.26±0.30 Aa	2.00±0.26 Aa	1.96±0.23 Ba	1.81±0.28 Aa	1.78±0.31 Aa	1.95±0.37 Aa
	A	2.84±0.28 Aa	2.74±0.31 Aa	2.68±0.28 Aa	2.60±0.66 Aa	2.51±1.34 Aa	2.50±0.23 Aa
	F	2.60±0.16 Aa	2.21±1.02 Aa	2.28±0.34 Ba	1.78±0.98 Aa	1.60±1.34 Aa	2.47±1.14 Aa
20	P	3.27±0.24 Aa	3.19±0.31 Aa	2.99±0.26 Aab	2.83±0.25 Aabc	2.36±0.14 Abc	2.14±0.27 Abc
	A	3.50±1.09 Aa	3.31±0.23 Aa	3.39±0.22 ABa	3.25±0.20 Aa	3.33±0.23 Aa	3.30±0.28 Aa
	F	3.59±0.24 Aab	3.49±0.19 Aab	4.04±0.27 Aa	2.26±0.28 Ab	3.16±0.38 Aab	3.29±0.18 Aab
30	P	3.60±0.28 Ba	3.26±0.22 Ba	3.20±0.19 Ba	3.18±0.31 Ba	2.92±0.22 Ba	2.85±0.33 Ba
	A	5.08±0.25 Aa	4.83±0.27 Aa	4.52±0.22 Aa	4.61±0.31 Aa	4.42±0.25 Aa	4.47±0.30 Aa
	F	4.13±0.21 ABa	4.12±0.31 ABa	4.51±0.22 Aa	4.26±0.36 ABa	3.97±0.06 ABa	4.02±0.11 Aa

During same storage period, means in the same columne without same capital sunerscrints differ significantly ($P<0.05$); means in the same line without same lowercase sunerscrints differ significantly ($P<0.05$). P, pre-rigor pork; A, ageing pork; F, frozen pork.

PL of three types of emusion-type sausage in the absence of phosphate was affected ($P<0.05$) by storage compared to added phosphate (0.1, 0.2, 0.3, 0.4, and 0.5%, respectively) sausage.

According to relationship between meat types and PL of emusion-type sausage, it had no significant difference ($P>0.05$) when sausages made with pre-rigor pork compared with ageing pork and frozen pork at 10 and 20 d storage. But, at 30 d storage, pre-rigor meat had lowest ($P<0.05$) PL in three types of sausage. Despite a lower value of frozen pork sausage, there was no significant difference ($P<0.05$) in PL of sausage made by ageing pork and frozen pork at 20 and 30 d storage.

With the increasing of phosphate, the ratio of PL between initial 10 d and total storage time decreased. When adding 0% phosphate, these ratio were 65.54, 55.89 and 61.90%, respectively for pre-rigor pork, ageing pork and frozen pork, and were 57.67, 56.48 and 42.86% at 0.3% phosphate.

From the foregoing it indicates that phosphates influence the distribution of PL of emusion-type sausage. Significant decrease of PL can not be obtained by increase of phosphate level at storage ($P>0.05$). Meat type is the key point to decrease the PL of emusion-type sausage.

Influence of phosphate on texture of emulsion-type sausage

Mean values for the hardness of emusion-type sausage for three meat types and six phosphate treatments during 30 d storage are shown in Fig.3. At both 0 and 30 d, the hardness among three types sausage made by different meat had no difference ($P>0.05$) when no phosphate was added; however, significant difference ($P<0.05$) appeared when 0.1-0.5% was added, even extremely significant difference ($P<0.01$) at 0.5% phosphate.

Hardness of emusion-type sausage significantly ($P<0.01$) increased despite of meat types during 30 d storage. When no phosphate was added, hardness increase are 100.83, 100.65 and 104.34 g for pre-rigor pork, ageing pork and frozen pork sausage during 30 d storage, respectively. Due to adding of phosphate (0.1-0.5%), hardness increase for pre-rigor pork sausage decreased from 56.32 to 34.09 g, while 0.5% phosphates does not contribute to texture stabilization of ageing pork and frozen pork sausage during storage for their hardness increase of 150.67 and 123.57 g.

On different storage period, hardness increase can be influenced by phosphate and meat type. When no phosphate added, there were significantly increases ($P<0.05$) on hardness of ageing pork and frozen pork sausage during 10-30 d storage compare to their 0-10 d data. However, with same phosphate additions, the increase trend is lower for pre-rigor pork sausage during storage. Texture stabilization effect of pre-rigor pork appeared after 20 and 10 d if phosphate were 0.1-0.3% and 0.4-0.5%.

Influence of pre-rigor/post-rigor and phosphate on microbial and sensory properity of emulsion-type sausage

According to Fig.4, more phosphates were used, less rudimental spoilage bacterial were found on sausage at

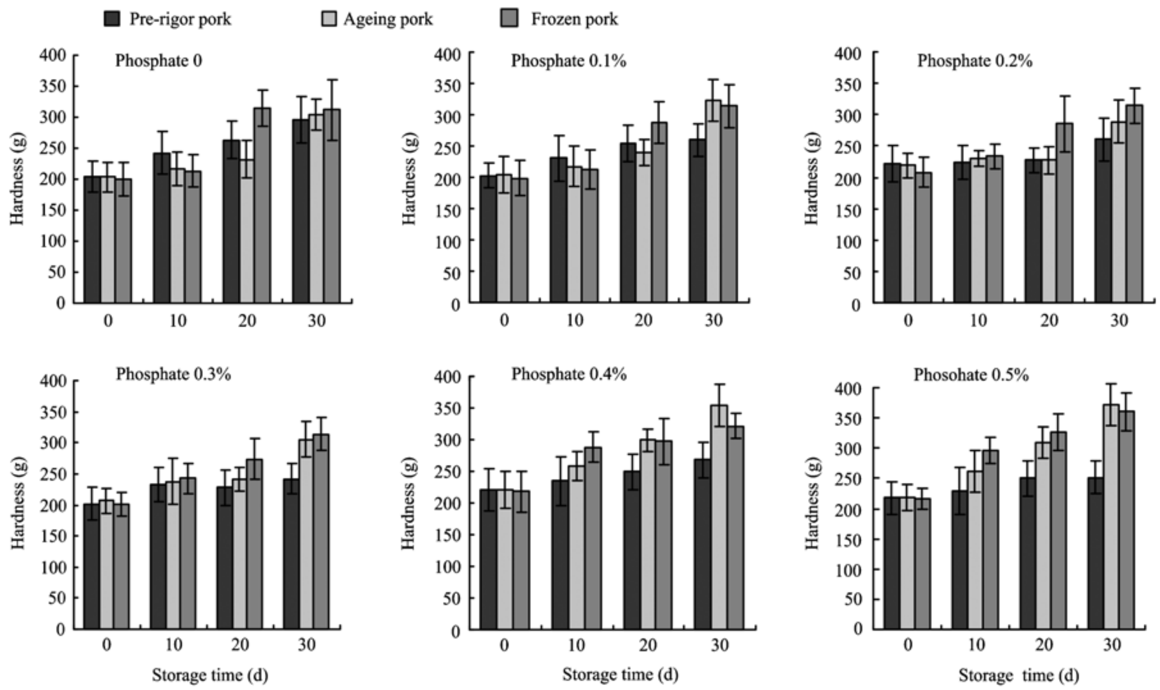

Fig. 3 Effects of meat, phosphate and storage on hardness of emulsion-type sausage.

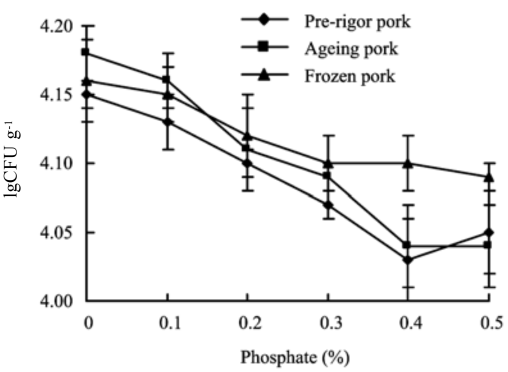

Fig. 4 Effects of meat and phosphate on total microbial number of emulsion-type sausage.

30 d. There were no difference ($P > 0.05$) on total microbial number of three types of sausage made by same phosphates at the end of storage.

At the beginning of storage, three types of sausage had desirable cured colour and flavour, proper hardness and springiness, and vacuumize film closely clinged to natural casing. But the color of sausage gradually faded when it closed to shelf life of sauage. After a 30-d storage, the sausage made by ageing meat obviously separated out water and fat at the gap between sausage and vacuumize film.

DISCUSSION

Phosphates are generally used in meat products to enhance WHC and improve yield. Puolanne *et al.* (2001) has calculated that phosphate addition caused an increase in water-holding of about 30-40 g water per 100 g meat. At 1.5% NaCl, Trout and Schmidt (1984) found a yield inceasing effect brought by sodium tripolyphosphate. Similarity with research of Lü and Zhang (2000), our research indicated the water-binding curve was not linear with added phosphates. There were considerable increases until levelling slowly off at 0.4%. It meaned that phosphate had a limitation for increasing effect in water-holding of sausage.

CL was significantly greater for postrigor salted muscle than pre-rogor salted muscle (Park *et al.* 1987). Our research also confirmed that pre-rigor salted muscle had economical advantage of improving yield. At 0.4% phosphates, pre-rigor meat reached yield of 98.95% compared to maximum yield of 97.96% of frozen meat at 0.5% phosphates, which showed a higher yield at lower phosphate for sausage made by pre-rigor meat.

Firmness of sausage increased when phosphates were used (Puolanne and Terrell 1983). Addition of phosphates increased gel stress and strain values both of pre-rigor and post-rigor meat, and pre-rigor meat has a great effect (Park *et al*. 1993). Hardness ratio of sausage made by hot deboned and cold deboned broiler meat was 15.04:11.45 (Lyon *et al*. 1983). Hardness of emusin-type sausage could be influenced by many factors. First, phosphate increase the extractability of muscle protein; then, meat in the pre-rogor state has better emulsifying capacity. So, stronger gel matrix with these ingredients is more chewinesser and hardnesser, and this texture is grateful by consumer. On the other hand, the increase in hardness is due to water loss from the sausage during refrigerated storage (Candogan and Kolsarici 2003). It may result in detrimental effect on sensory quality. This research also found that for sausage of lower initial hardness value, rapider increasing of hardness could be found during storage. This may because that poor gel matrix in low hardness sausage can not effectively hold water and fat comparing to stronger gel matrix in high hardness sausage.

Rapid freezing and short period sorage were adopted by frozen meat which used in our research. So functional property of it was maintained for less denaturalization of meat protein. This might be one reason of similar hardness of sausage between pre-rigor meat and frozen meat at initial storage. But in industy practice, frozen of meat may result in a loss of functional property when it undergoes long frozen period and temperature fluctuation during storage (Huang 2005).

Sensory evaluation is the science of judging and evaluating the quality of a food by the use of the senses, i.e., taste, smell, sight, touch, and hearing (Sidel and Stone 1993). Texture profile analysis (TPA) has been widely used as an instrumental method, providing information on both the deformation and fracture properties of food. Textural properties were obtained from force-time curves after two compressions under measuring probes. Because there is a correlation between sensory and instrumental measurement of sausage texture (Dong and Luo 2004), degradation of sensory quality of sausage in shelf life should be a result of synergistic effect of hardness increasing and purge loss.

There are at least four functional properties for phosphates that can be used in meat products: cleaving the actomyosin bond, increasing the ionic strength, changing pH, and binding to divalent cations (Han *et al*. 2004). Pyrophosphate and tripolyphosphate can bring a transverse expansion of the myofibrils with a simultaneous extraction of myosin from the ends of the A-band in the sarcomere. These structural/biochemical changes result in substantial swelling of muscle fibers, and an enhanced water uptake and immobilization is achieved (Xiong 2005). Solubilizing of salt-souble protein that is important to water-holding of meat product can be gotten by synergistically acting of salt and phosphates (Peng 2005). With added phosphates, the water-holding curve is not linear in relation to NaCl content. At low contents, up to 1.0% NaCl there is a linear relationship, but then water-binding increases considerably until levelling slowly off at 1.5% (Ruusunen and Puolanne 2005). The study on carp found that phosphate addition significantly increased the emulsification capacity (EC) for the samples with 0 and 1.0% salt, but the effect of phosphate on the EC was not statistically significant for the samples containing 2.0% salt (Yapar *et al*. 2006). The use of phosphate effectively decreased cooking loss, particularly of low-sodium ($\leqslant$ 0.8%) patties (Ruusunen *et al*. 2005).

Thus, on our research, phosphates may lack a significant influence on WHC of emusion-type sausage for 3% NaCl. Excessive intake of sodium has been linked to several of harmful effects. So, phosphates will be promising in lowering the NaCl content in meat products.

Similar to the result of Bai *et al.* (2006), they reported that the growth of rudimental spoilage bacteria during storage could slowly increase total microbial number of sausage, and there was no siginificant difference for all bacteria of three types of sausages. It means that pre-rigor meat is microbial safety for making emusion-type sausage so far as the assurance of sanitation and low temperature, and preblending of pre-rigor meat will be extensivly used with the development of cold chain logistics in China.

CONCLUSION

With higher processing yield, lower PL and more steady texture quality, pre-rigor meat improved WHC and texture of emulsion-type sausage comparing to ageing meat and frozen meat. Meanwhile, degradation of water-holding capacity and texture of emulsion-type sausage during storage could not be resolved by single use of phosphate at relatively higher level (3%) of NaCl.

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