THE RELATIONSHIP BETWEEN TWO-TONED PORK HAM MEAT AND COOKED HAM QUALITY

Yuan-Jhen Huang, Pei-Li Chen and Kou-Joong Lin

Department of Animal Science, National Chiayi University, Chiayi, Taiwan

*Corresponding author (phone: 886-5-271-7537; fax: 886-5-275-8725; e-mail: kjlin@mail.ncyu.edu.tw)

***Abstract*—The aim of this study was to investigate the relationship between two-toned pork ham and cooked ham quality. The portion cut ham of *Semimembranosus* (SM) and *Quadriceps femoris* (QF) were classified into three groups - dark pork ham meat (Group I), light pink pork ham meat (Group II), and mixed pork ham meat (Group III) that was mixed SM and QF. Physicochemical properties, phosphatase activity and sensory evaluation for 6 weeks were determined. The results shown in color that a value of samples made from Group I was significantly highest, but in L value and b value were the lowest ($P<0.05$). The pH value of samples made from Group II was significantly lowest ($P<0.05$). The TBARS value of samples made from Group I was highest after 6 weeks ($P<0.05$). Nitrite residue of samples made from Group I was highest at previous 3 weeks ($P<0.05$), but samples made from Group I and Group III both decreased quickly after 5 weeks of storage, samples made from Group II was the highest ($P<0.05$). In total plate count (TPC), all samples were increased with refrigerated storage time, and samples made from Group III was higher than the others after 2 weeks of storage. In sensory evaluation, color scores of sample made from Group I was higher. Sensory scores and overall acceptance of samples made from the Group II was the lowest. Phosphatase activity of all groups had significant difference ($P<0.05$). After cooking, the phosphatase activity of all samples decreased quickly, but the samples made from Group I had higher residual activity; furthermore, all samples contrast with the standard curves for phosphatase activity, it exhibited all samples cooked to reach 71℃ internal temperature.**

***Index Terms*—two-toned meat, cooked ham, phosphatase activity.**

I. INTRODUCTION

The appearance of processed meat product is of primary importance in modern marketing as most consumers buy “by the eye” (Schulz, 1989). The color difference in porcine muscle often affected by the ratios of red fibers and white fibers, it was particularly apparent in two-toned meat of pork ham muscle. It had been reported by others (Briskey, Bray, Hoekstra Phillips & Grummer, 1960 ; Lewis, Heck, & Brown, 1961), specifically postmortem changes in the extent or rate of glycolysis can create variation of muscle pH result in two-toned meat. The most significant difference was soft, lower concentration of myoglobin and watery appearing in pale pork muscle due to initial muscle glycogen concentration and the rate of pH decline (Briskey, Bray, Hoekstra, Phillips & Grummer, 1959). There were also extensive reviews of the physical and biochemical properties of red and white muscles during recent years. Klont, Lambooy & Van Logtestijn (1993) indicated that myofibers are commonly categorized as red fiber, white fiber, or intermediate fiber. The red fibers and white fibers, also known as slow-oxidative and fast-glycolytic, respectively, represent two extreme metabolic profiles. Red fibers have a higher concentration of myoglobin, generally lower in glycogen and higher in lipid content than white fibers, and high in oxidative enzymes. White muscles were high in glycolytic enzymes and they twitch faster in response to stimulation than red muscles (Henckel, Oksbjerg, Erlandsen, Barton-Gade & Bejerholm, 1997), and have a faster rate of pH decline and enter rigor earlier than red fibers (Klont, Brocks, & Eikelenboom, 1998). The fibers are intermediate fast oxidative-glycolytic fibers, its properties was between red fibers and white fibers. The fiber type was easy to influenced easily by many factors, for instance, environmental, genetics, nutrition and exercise (Gentry, McGlone, Miller & Blanton, 2004), as well as the different types differ in their rate of glycolysis and proteolysis result in the variation of biochemical and physical properties in skeleton muscle. Therefore, it was possible that fiber type composition associated with postmortem changes in the conversion of muscle to meat and subsequently meat quality.

Otherwise, in order to confirm the processed meat if endpoint temperature (EPT) have been met food safety regulations, many researchers were devoted to develop effective methods to estimate, and phosphatase test was recognized as an important method. Lien *et al.*(2002) reported that phosphatase decreased as the EPT increased, and the activity was highest below 65.8℃, at 71.1℃ decreased rapidly and stable. So the activity of phosphatase ratio could be used as an indicator of temperature attained in pork product. Davis & Townsend (1994) also indicated that phosphatase activity among turkey dark muscle, turkey breast , and broiler breast(white muscle) were heated to the same temperature, it shown the turkey dark muscle had inherently lower phosphatase than others and broiler breast continues to decreased at a greater rate than others with increasing EPT. Therefore, it may be need to establish phosphtase/EPT equations for two-tone meat to assured the EPT was up to the standard.

Our current commercial cooked ham often made from pork ham, but very little research has been conducted on the unity of meat color. Therefore, the objective of this experiment was expected to select meat of cooked ham by color, to investigate the physicochemical characteristics during storage and relationship between two-toned pork ham and cooked ham quality.

II. MATERIALS AND METHODS

A. Cooked ham manufacture

Cooked ham were prepared with *Semimembranosus* (SM) and *Quadriceps femoris* (QF) which were purchased from a local company. Lean tissue was trimmed of heavy connective tissue and external fat, and then divided into three groups - dark pork ham meat (Group I) and light pink pork ham meat (Group II) were selected by visual color, the control group was mixed SM and QF by 1:1 (Group III). All three groups grounded through kidney shape plate, formulated with 3% sugar, 2% salt, sodium phosphate (0.25%), sodium erythorbate (0.05%), sodium nitrite (0.015%) and 15% ice water, then tumbling, massaging and curing at 0-4°C for 3 days. The cured meat were manufactured by the following proceeded of commercial cooked ham. The cooked ham were stored at 0-4℃ and analyzed at 0-6 weeks. Three replicates with batches were conducted in this study.

B. Physicochemical analyses

The pH value were determined with 10g minced samples plus 90 ml of distilled water and homogenized were measured by a pH meter (SP-2200, Suntex, Taiwan) as described by Ockerman (1972). Approximately 5g minced samples were placed in a measuring container, and then the Hunter L (lightness), a (redness), and b (yellowness) values of samples were measured with a color meter (Color difference meter, Model TC-1, Tockyo Denshouku CO, LTD., Japan). Thiobarbituric acid reactive substances (TBARS) of samples were determined using the methods as described by Faustman, Specht, Malkus & Kinaman (1992). TBARS were expressed as mg malonaldehyde per kg samples. The method of the Chemistry Laboratory Guidebook of USDA for nitrite residue measurement. Microbiological analyses were determined in triplicate using the method of Bacteriological Analytical Manual for Foods (BAM) of FDA. The method of Davis & Townsend (1994) for phosphatase measurement. Phosphatase enzyme was extracted from samples which mincing and weight 5g meat plus 50g distilled water into mixer cup. The cup with sample was placed in an ice/water bath and blended at high speed (16000 rpm) for 1 min. The resulting slurry were centrifuged at 2℃ with 15000 rpm (HITACHI himac SCR 20B, Japan) for 10 min, and then filtered through Toyo No.1 filter paper. The clean extract was placed in a ice/water bath until analyzed and standard curve for phosphtase/EPT was conducted via the method by Kuo & Huang (2003). Sensory evaluation needs fifteen untrained panelists evaluated acceptance of color, tenderness, juiciness, texture, flavor, and overall acceptability of cooked ham samples. At 0-6 weeks of storage, the sensory evaluation was conducted using a 1–7 scale, with 1 representing the lowest acceptance and 7 the highest acceptance for all attributes.

C. Statistical analysis

Analysis of variance was performed on all the variables measured using the GLM procedure in SAS 9.1 (2002), and Turkey's test was used for the analysis of significant differences.

III. RESULTS AND DISCUSSION

No significant difference between three groups during storage time, but the L value and b value of the samples of Group I were significantly lowest, and reversely the a value was significantly highest ($P<0.05$). Tseng, Lin & Yang (1990) indicated that cooked ham made from chicken dark muscle and white muscle, which shown that different muscle type affected the percentage of myoglobin and metmyoglobin in meat, resulted in difference of processed product. Our results were as reviewed by above mentioned. Moreover, as was previously reported by Lin (1989), due to quite obvious two-toned meat of pork ham muscle, the samples of Group III had divergent data in ‘‘a value” of statistics during storage, and the appearance color of samples of Group III was non-uniform.

The pH value of three groups were no significant difference during storage time and ranged from 6.12-6.70 (Fig 1), but the pH value of samples of Group II was significantly lowest ($P<0.05$). From Tseng *et al.* (1990) reported that higher white fibers proportion of white muscle, which had higher glycogen concentration and an increased number of lactic acid at post-mortem, caused products to have lower pH value. Our results were similar with the previously reviewed reports.

The TBARS values of all samples increased slowly after 4 weeks of storage, but samples of Group I was higher than the others after 6 weeks of storage (P<0.05) (Fig 2). Much works had been done on the characteristics between different types of muscle fibers and the variation in fiber type characteristics could explain part of the variation in some meat quality traits. Upon review of the previously work by Morcuende, Estévez, Ruiz & Cava (2003), slow-twitch oxidative fibers (type I) had higher polyunsaturated fatty acid, more oxidative, and triglyceride hydrolysis than fast-twitch glycolytic fibers (type IIb). Also, it found the muscles had higher concentration of myoglobin, resulted in much more Fe^{2+} of heme transfered to Fe^{3+}. Previously studies could be the causes of the promotion of lipids oxidation leading to rancidity in Group I.

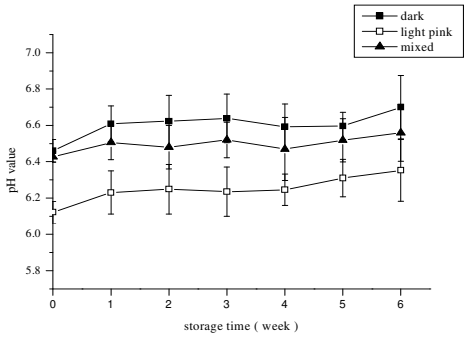

Fig. 1. The change in pH value of cooked ham made from dark, light pink, and mixed pork ham at at 0~4℃ refrigerated storage for 6 weeks.

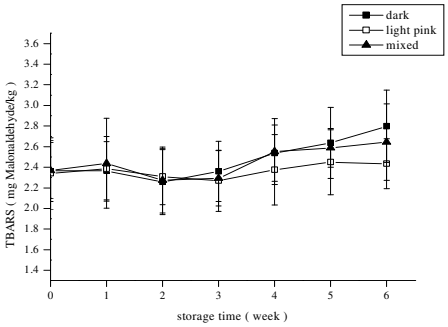

Fig. 2. The change in TBARS value of cooked ham made from dark, light pink, and mixed pork ham at 0~4℃ refrigerated storage for 6 weeks.

Nitrite residue of all samples were under 70 ppm that allowed with the Department of Health in Taiwan (Fig. 3). Nitrite residue of samples of Group I was highest at previous 3 weeks of storage (P<0.05), it was possible that higher pH value of samples of Group I decreased nitrite depletion (Thelier, Sato, Aspelund & Miller, 1981). However, the nitrite residue of samples of Group I and Group III both significantly decreased at a greater rate after 5 weeks and under 50 ppm (P<0.05). Contrast to total plate count (TPC) (Fig. 4), the data showed TPC increased quickly at the same time. The samples of Group II had lower nitrite decline and the great amount of nitrite residue.

TPC of all samples were increased with refrigerated storage time (Fig. 4). However, the TPC of samples of Group III were higher than the others after 2 weeks; it also showed that exceeded 1×10^6 CFU/g of the requirement of CAS (Chinese Agriculture Standards) after 6 weeks. It suggested the quality of samples of Group III were unstable, but which reason to be needed further research. Also, the TPC of samples of Group II were lowest and were observed from 3.91-4.68 log CFU/g, the results were similar to reported by Roberts, Gibson & Robinson (1981), it indicated that higher pH value was advantageous to the growth of microorganism.

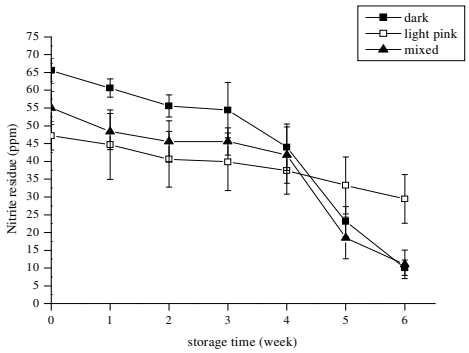

Fig 3. The change in nitrite residue (p.p.m.) of cooked ham made from dark, light pink, and mixed pork ham at 0~4℃ refrigerated storage for 6 weeks.

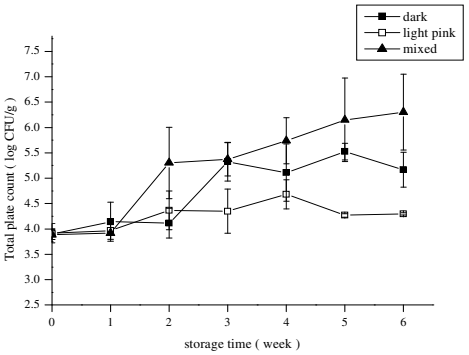

Fig 4. The change in total plate count (log CFU/g) of cooked ham made from dark, light pink and mixed pork ham at 0~4℃ refrigerated storage for 6 weeks.

The sensory evaluation results were shown that samples of Group I and Group III both were gained the better scores, however, samples of Group I had great acceptability in color evaluation. The samples of Group II were gained lower scores in all items and had the lowest overall acceptance (P<0.05).

Phosphatase activity of two-toned pork ham meat had significant difference (P<0.05) (Table 1). After water cooking, the phosphatase activity of all samples decreased quickly and three groups had different decay of decrease, the result were similar with previously reported by Davis & Townsend (1994), it suggested that phosphatase decreased in a

curvilinear response to EPT and was muscle-type dependent. However, our results found the samples of Group I were higher than the others. Furthermore, all samples contrast with the standard curves for phosphatase activity (Fig. 5), it exhibited all samples cooked to reach 71℃ internal temperature. If used phosphatase as an monitor of EPT attained, it was needed to establish phosphatase/EPT curve for two-toned meat products.

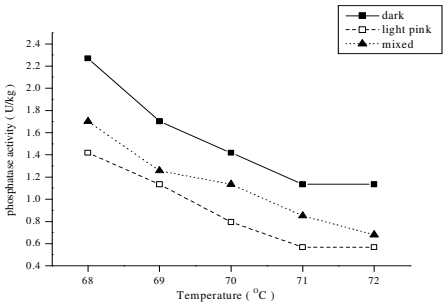

Fig. 5. Effect of increasing endpoint temperature on phosphatase activity in dark, light, and mixed pork ham meat.

Table 1. The phosphatase activity of two-toned pork ham meat and cooked ham made from dark, light, and mixed pork ham.

	phosphatase activity(U/kg)	
Treatment	uncooked	cooked (71℃)
dark pork ham	425.13±15.63[a]	1.29±0.46[a]
light pink pork ham	294.94±8.22[c]	0.56±0.28[b]
mixed pork ham	358.72±15.02[b]	0.81±0.51[ab]

IV. CONCLUSION

The importance of meat color in consumer acceptance is well known. In our study, we found significant difference of various meat trait among three groups, it shown that each group had it's own good and bad aspects. We could use their difference of characteristics to develop different product respectively to increase the economical value of processed product.

REFERENCES

Briskey, E. J., Bray, R. W., Hoekstra, W. G., Phillips, P. H., & Grummer, R. H. (1959). The chemical and physical characteristics of various pork ham muscle class. *J. Anim. Sci.*, 18, 146-152.

Briskey, E. J., Bray, R. W., Hoekstra, W. G., Phillips, P. H., & Grummer, R. H. (1960). Effect of high Protein, high Fat and high sucrose rations on the water-binding and associated properties of pork muscle. *J. Anim. Sci.*, 19, 404-411.

Davis, C. E. & Townsend, W. E. (1994). Rapid fluorometric analysis of acid phosphatase activity in cooked poultry meat. *J. Food Prot*., 57(12), 1094-1097.

Faustman, C., Specht, S. M., Malkus, L. A., & Kinaman, D. M. (1992). Pigment oxidation in ground veal : influence of lipid oxidation iron and zinc. *Meat Science*, 31, 351-362.

Kou-Joong, Lin. (1989). Effect of chilling and frozen treatments on qualities of dried seasoned pork muscle and cooked ham made from mechanically anaesthesia and electrical stunning slaughtered pig's ham. *Journal of the Chinese Society of Animal Science*, 18(3-4), 87-98.

Gentry, J. G., McGlone, J. J., Miller, M. F., & Blanton, J. R. Jr. (2004). Environmental effects on pig performance, meat quality, and muscle characteristics. *J. Anim. Sci*., 82, 209-217.

Chun-Chin, Kuo & Chun-Lin, Huang. (2003). Activities of acid phosphatase and pyruvate kinase and water-extractable protein ratio of ground duck breast muscle as affected by sodium chloride and endpoint temperatures. *Taiwanese Journal of Agricultural Chemistry and Food Science*, 42(1), 15-22.

Henckel, P., Oksbjerg, N., Erlandsen, E., Barton-Gade, P., & Bejerholm, C. (1997). Histo- and biochemical characteristics of the longissimus dorsi muscle in pigs and their relationship to performance and meat quality. *Meat Science*, 47, 311-321.

Klont, R. E., Brocks, L., & Eikelenboom, G. (1998). Muscle fibre type and meat quality. *Meat Science*, 49, 219-229.

Klont, R. E., Lambooy, E., & van Logtestijn, J. G. (1993). Effect of pre-slaughter anaesthiesia. *J. Anim. Sci.*, 71, 1477-1485.

Lewis, P. K., Heck, M. C. Jr., & Brown, C. J. (1961). Effect of stress from electrical stimulation and sugar on the chemical composition of swine carcasses. *J. Anim. Sci.*, 18, 1080-1086.

Lien, R., Hunt, M. C., Anderson, S., Kropf, D. H., Loughin, T. M., Dikeman, M. E. & Velazco, J. (2002). Effects of endpoint temperature on the internal color of pork loin chops of different quality. *J. Food Sci.*, 67(3), 1007-1010.

Morcuende, D., Estévez, M., Ruiz, J. & Cava, R. (2003). Oxidative and lipolytic deterioration of different muscles from free-range reared Iberian pigs under refrigerated storage. *Meat Science*, 65, 1157-1164.

Ockerman, H. W. (1972). Quality control of postmortem muscle tissue. p. 120. The Ohio State University and the Ohio Agricultural Research and Development center. U.S.A.

Roberts, T. A., Gibson, A. M., & Robinson, A. (1981). Factors controlling the growth of clostridium botulinum type A and B in pasteurized cured meats II. Growth in pork slurries prepared from high pH meat. *J. Food Technol.*, 16, 267-270.

Schulz, E. (1989). A food retailers requirements to future meat and meat products. In Proceedings 35th international congress of meat science and technology (pp. 9–15), 20–25 August, Copenhagen, Denmark.

Theiler, R. F., Sato, K., Aspelund, T. G., & Miller, A. F. (1981). Model system studies on N-nitrosamine formation in cured meat : The effect of curing solution ingredients. *J. Food Sci*. 46, 996-999.

Tsai-Fuh, Tseng, Kou-Joong, Lin, & Jheng-Huh, Yang. (1990). Studies on the improvement of chicken cooked ham Processing. I. yields, color, microbiology contents and storage qualities of spent chicken cooked ham as affected by drying and cooking internal temperature. *Journal of the Chinese Society of Animal Science*, 19(3-4), 139-157.