**Effects of Cooking Time on Chemical and Rheological Properties in the Marinated and Spiced Pork Shank**

Hsiu-Lan Guo[1] and Ming-Tsao Chen[2]
1.Dept. of Food Nutrition, China J. College Medical Technology. Tainan,Taiwan, R.O.C.
2.Dept. Of Animal Science,Chung-Hsing University.Taichung,Taiwan,R.O.C.

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**Introduction**

Pork is one of the highest consumption in Taiwan. There are different cooking methods for preparing meat, which are dependent on parts of pig and localities. Generally, loin is used for steaks or pork chops, and soup. Belly and tenderloin are used for frying, roasting or marinating. Shank is used for marinating and spicing. Chinese require eating quality of meat to be not only tender but fragile and elastic. During cooking the cooker have to control heat and cooking time carefully to get the delicious food by their experience but not methodology. Considerable research has been reported and demonstrated that tenderness is affected by cooking rate, temperature, time and cooking methods ( Robertson et al., 1984; Belk et al., 1993; Wu et al.,1995 ). Seideman(1986) also indicated that change in collagen caused by cooking would affect the tenderness of meat. Changes in chemical and physical properties of collagen and their relation to sensory quality by Chinese-style cooking have been less extensively studied. Therefore, this research represented an effort to evaluate how the cooking time affect the palatability of pork.

**Materials and Methods**

**Marinated and spiced pork shank preparation** Pork shank was obtained about 8 hr postmortem from the local market. The shank was cut into 10 cm thick and boiled to an internal temperature of 70 ℃ ( welldone ) . Samples were checked at 0,15,30,45,60,75 and 90 min., respectively. Then the cooked products were marinated and spiced at 10 ℃ overnight for analysis. The sensory and rheological properties and collagen content were determined for studying the effects of cooking time on palatability of the marinated and spiced pork shank.

**Sensory evaluation** Pork shank ( 0.5 cm thick ) was served duplicately to an 6-member panel ( trained ) . Panelists were asked to evaluate texture and tenderness ( 1=undesirable, 6=extremely desirable ) .

**Texture profile analysis** Texture profile analysis was performed using SMS-STRA Dimension analyzer ( England ) . The objective portion of the texture profile was partitioned into chewiness, cohesiveness, hardness and springiness attributes. The conditions were as follows:

| | | |
|---|---|---|
| force units:grams | adapter contact area:1.13mm$^2$ | strain:30%,time:5 sec |
| test speed and post speed:5.0mm/sec | pre-test speed:5.0mm/sec | contact force:5.0g |

**Chemical analysis** The ground samples were weighted, extracted with distilled water, filtered and the filtrates were used for measuring O.D. at 600 nm to determine the soluble protein content. Samples were treated using the procedure described by Hill ( 1966 ) Collagen and soluble collagen contents were measured by the methods of Stegeman and Stalder ( 1967 ) .

**Statistical analysis** ANOVA were used to test the significance of treatment effect. When significant ( $p<0.05$ ) differences were found, means were separated by the Duncan's multiple range test. Data were analyzed using a statistics software package ( SAS Institute Inc.,1987 ).

**Results and Discussion**

The result of sensory evaluation of the marinated and spiced pork shank was presented in Fig. 1. Tenderness scores were different ( $p<0.05$ ) between 30 and 45 min. of cooking times, and the scores of tenderness decreased with increasing cooking time. Differences ( $p<0.05$ ) in the texture of pork shank were observed at the cooking time between 45 and 60 min. The acceptability of the pork shank decreased as cooking time increased from 45 to 60 min. It was observed that the acceptability of texture and tenderness was lowest for the pork shank after one hour cooking. Appearance of the cooked pork shank samples with different cooking tines was shown in Fig. 5. The picture showed that the cooked pork shank samples became crispy and brown around the outside crust after 60 min. cooking, and the sample became cracked at 75 min. of cooking time. After 90 min. cooking, the sliced pork shank was shredded, and could not be pick up a whole pick of sample with chopsticks.

The results of rheological measurement were shown in Fig. 2. and Fig. 3. The springiness and cohesiveness of the pork shank samples decreased as increasing cooking time. There were significant differences ( $p<0.05$ ) in springiness for 45 min. cooking from that of other cooking times. And the differences in the cohesiveness of the pork shank samples were found at 30 min. cooking, chewiness, gumminess and hardness of the pork shank samples were significant different ( $p<0.05$ ) between 15 min. and 0 min. of cooking times ( Fig. 3. ) , and the data of measurement decreased as increasing cooking time. To compare Fig. 1,2, and 3, the results were found that the sensory sensitive area of pork shank was between 45 and 60 min. of cooking time.

Chemical analyses of pork shank were shown in Fig. 4. The soluble protein content increased as increasing cooking time. There were significant differences ( $p<0.05$ ) in the soluble protein content of the pork shank cooked at 15 min. from other cooking time, but no significant difference was detected from the samples cooked at 75 to 90 min. of cooking time due to the protein solubilized in the soup. However no remarkable decrease in total collagen content was observed after the samples cooked for 15 min., and the soluble collagen content increased after 30 min. cooking.

The result of the general linear multiple regression indicated that texture profiles and chemical analyses were closely related to tenderness of palatability. The relationships between the rheological properties or chemical analyses and sensory attributes were evaluated with the model of SAS ( 1987 ) :

$Y=161.02X_1^2-282.74X_1+126.52$ ( $R^2=0.9833$ ) $Y=0.0005X_5^2-0.1867X_5+18.990$ ( $R^2=0.9484$ )

$Y=28.747X_2^2+24.465X_2-0.3293$ ( $R^2=0.9007$ ) $Y=13.013X_6^2-56.936X_6+64.505$ ( $R^2=0.8137$ )

$Y=0.0004X_3^2-0.092X_3+8.3148$ ( $R^2=0.9344$ ) $Y=4.2335X_7^2+0.2314X_7+1.8947$ ( $R^2=0.8625$ )

$Y=0.0003X_4^2-0.0867X_4+8.082$ ( $R^2=0.9913$ ) $Y=1.1035X_8^2-2.622X_8+3.9875$ ( $R^2=0.8801$ )

Y=tender

$X_1$=springiness $X_2$=cohesiveness $X_3$=chewiness $X_4$=gumminess
$X_5$=hardness $X_6$=total collagen $X_7$=soluble collagen $X_8$=slouble protein

Simple correlation coefficients for all measurements were presented in Table 1. The correlation between the percentage area of sensory and rheological measurements was in the range -0.86 to -0.93. The correlation between sensory and soluble components was in the range of 0.88 to 0.92 but only -0.74 to -0.73 as compared with total collagen.

Many factors have been associated with tenderness in muscle such as cooking rate, cooking temperature, cooking type and size of portion(Robertson et al.,1984;Wu et al.,1995;Belk et al.,1993). Seideman(1986) documented that the effects on tenderness by cooking were 1).contraction of the myofibrillar structure, 2).the connective tissue structure and 3). the water holding capacity of the muscle proteins. The important mechanisms during cooking were myofibrillar structure losing moisture and shrinking but the collagen fibers of the intramuscular connective tissue net work will be restrained by the interstitial materials. He was also demonstrated that the highly correlation coefficient was found between soluble collagen and textural properties.

**Conclusion**

This study concluded that cooking time might influence sensory chemical and rheological properties of pork shank. The hardness of the samples increased as increasing cooking time, when moderately cooking was used to prepared pork shank. The lower palatability of tenderness was detected after 45 min. cooking. The soluble protein and soluble collagen contents were found to be positive correlation to tenderness, whereas, the total collagen and the texture analyses were negative correlation to tenderness. It was noted that the correlation coefficients of all the rheological data were most highly correlated($r^2$>0.85) and total collagen were the next($r^2$>0.70) highly correlated to the sensory properties.

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Table 1. Simple regression correlation coefficients among sensory, and chemical measurements for pork shank cooked for different times.

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1.texture | 1 | | | | | | | | | |
| 2.tenderness | 0.9815 | 1 | | | | | | | | |
| 3.springness | -0.8765 | -0.9082 | 1 | | | | | | | |
| 4.cohesiveness | -0.8769 | -0.9334 | 0.8575 | 1 | | | | | | |
| 5.chewiness | -0.8637 | -0.8733 | 0.9674 | 0.8606 | 1 | | | | | |
| 6.gumminess | -0.9183 | -0.9325 | 0.9873 | 0.8852 | 0.9737 | 1 | | | | |
| 7.hardness | -0.9183 | -0.9325 | 0.9873 | 0.8852 | 0.9731 | 1 | 1 | | | |
| 8.soluble protein | 0.8825 | 0.8883 | -0.9340 | -0.8985 | -0.9789 | -0.9655 | -0.9655 | 1 | | |
| 9.soluble collagen | 0.8862 | 0.9236 | -0.8953 | -0.9786 | -0.9223 | -0.9289 | -0.9289 | 0.9645 | 1 | |
| 10.collagen | -0.7434 | -0.7709 | 0.9637 | 0.7450 | 0.9520 | 0.9415 | 0.9415 | -0.9002 | -0.8143 | 1 |

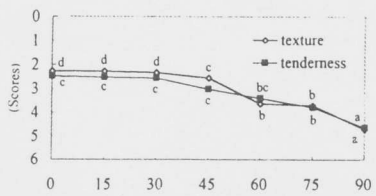


Fig. 1.Texture and tenderness scores of pork shank prepared with different cooking times. ( min )

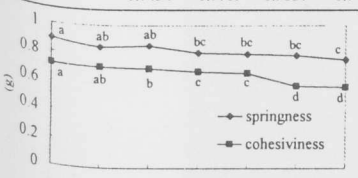


Fig. 2. Changes in the data of springiness and cohesiveness measurement of pork shank prepared with different cooking times. ( min )

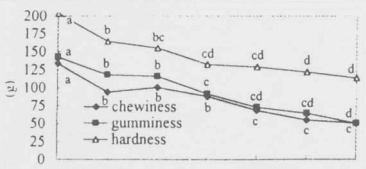


Fig. 3. Changes in rheological measurements of pork shank cooked at different times. ( min )

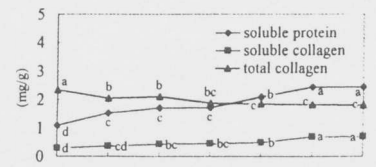


Fig.4. Changes in contents of soluble protein, soluble collagen and total collagen of pork shank cooked at different times. ( min )

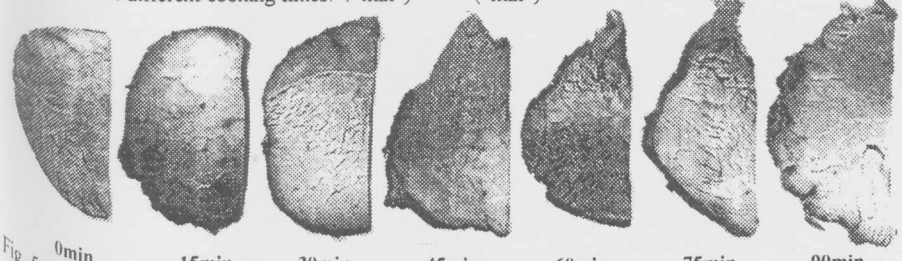


Fig. 5. Changes of appearance of pork shank cooked at different times.