COMPARISONS of the TRANSGLUTAMINASE ACTIVITY, RHEOLOGICAL PROPERTIES and MICROSTRUCTURE of PIG and POULTRY BLOOD

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INTRODUCTION

Blood Factor XIII (plasma transglutaminase) is a circulating plasma zymogen that is activated in the presence of Ca^{2+} and thrombin. The active enzyme, Factor XIIIa, catalyses the formation of ε-(γ-Glutamyl) lysine cross-links between the side chains of associated fibrin molecules, enhancing clot rigidity(Feldman and Winkelma, 1991; Smith *et al.*, 1988). In Taiwan, this property was utilized to put poultry or pig blood into glutinous rice. After natural blood clotting, the blood will attach itself to the rice. Good blood cakes can be produced after the cooking treatment. Blood cake is a quite popular traditional Chinese snack food. But the quality of blood cake was affected by different blood sources(Liu *et al.* 1993). Therefore, this research is to compare the transglutaminase activity from different blood sources and also to study rheological properties and microstructure changes of pig , chicken and duck blood after natural clot and curd with cooking so that we can better use blood to making blood cakes and other products requiring blood.

MATERIALS AND METHODS

The source of blood: Pig blood and chicken blood were collected from marketed pigs and commercial broiler. The duck blood was from mule duck (White Pekin drake × Tsaiya duck). **The plasma:** Blood samples randomly collected from of 30 pigs, chickens and ducks. The plasma samples obtained by centrifuging(1,000 × g, 15 minutes, 4 ℃)(Karges, 1984). **Determination of enzyme activity:** TGase activity was measured according to procedures followed in tests made by Folk and Cole (1966). **Determination of rheological property:** Rheological property was measured according to procedures followed by Sakamoto *et al.* (1995). **Scanning electron microscopy:** The lyophilized specimens were then put onto double-sided adhesive tape and then mounted on aluminum stubs. Mounted specimens were gold coated, examined using a scanning electron microscope(SEM, TOPCON ABT-150S) and finally recorded through photos (Ashie *et al.*, 1997). **Statistical analysis:** Statistical analyses of the data was conducted by applying Duncan's new multiple range test using the statistical analysis system (SAS, 1991).

RESULTS AND DISCUSSION

TGase activity of the plasma and breaking strength of clots from pig and poultry blood

Table 1 showed the comparison between the pig and poultry blood TGase activity. The results indicated the pig plasma has the highest content of protein(2.26 mg) and TGase activity (1.61 units)($p<0.05$). As to enzyme specific activity, duck plasma was the highest (0.75) but the chicken plasma was the lowest (0.40)($p<0.05$). In addition, this test shows pig plasma specific activity was 0.71 which was almost the same as the pig plasma specific activity 0.69 reported in tests made by Jiang and Lee (1992).

The clot breaking strength (122g)of duck blood was higher ($p<0.05$) than that of both pig (87g) and chicken blood (45g)(Figure 1). This results were probably because duck blood had higher enzyme specific activity(Table 1) which caused highly ε-(γ-Glutamyl) lysine cross-links to form between fibrin monomer molecules that form the denser of duck blood fibrin clots (Figure 3c) , insoluble clot, enhancing rigidity (Feldman and Winkelma, 1991; Smith, 1988).

Breaking strength of the pig and poultry blood curds with cooking

After cooking at 80 ℃ for 30 minutes, the breaking strength of pig blood curd was 928g, chicken blood curd 480g, and duck blood curd 1130g(Figure 2). this result indicated that pig blood curd and duck blood curd had a higher breaking strength than chicken blood curd($p<0.05$). But these three blood curds did not have obvious variation when cooked at 80 ℃ for 60 minutes. However, the breaking strength of all samples cooking at 90 ℃ for 30 minutes were significantly higher than that of cooking at 80 ℃ for 30 or 60 minutes. This result was probably because of the plasma binding protein gel structure got stronger by heat-induced (Dill and Landman, 1988; Hickson *et al.*, 1980; Hickson *et al.*, 1982). The plasma gel firmness was influenced by plasma concentration, treatment temperature and duration, pH and sodium chloride concentration(Knipe, 1988). Beside, Seguro *et al.* (1995) also indicated the breaking strength of the gels could be influenced by not only ε-(γ-Glutamyl) lysine cross-links , but also many other factors, such as unfolding of protein molecules by heat, disulfide bonds, hydrophobic interactions and hydrogen bonding. In addition, both chicken blood curd and duck blood curd have a higher breaking strength when the temperature and cooking time was increased. This result may be to larger viscoelasticity(Dill and Landman, 1983; Seguro *et al.*, 1995). Breaking strength of pig blood curd decreased when the curds were cooked for 60 minutes at 90 ℃. This result may be why the pig blood curd gel became rigid and brittle(Seguro *et al.*, 1995).

Microstructure of the pig and poultry blood clots

The microscopic structure of duck blood fibrin clots was denser when observed under scanning electron microscope(Figure 3c). However, the fibrin clot in pig blood was looser(Figure 3a). Chicken blood fibrin clots structure had larger porous network(Figure 3b). This result could be referenced by a higher enzyme specific activity in duck blood plasma(Table 1) and at higher breaking strength of duck clot in this experiment(Figure 1). And also could be explain by highly ε-(γ-Glutamyl) lysine cross-links to form between fibrin monomer molecules that form the denser of blood fibrin clots (Feldman and Winkelma, 1991; Smith, 1988).

CONCLUSIONS

TGase specific activity of duck plasma and breaking strength of duck blood clots had the highest but those of the chicken blood had the lowest ($p<0.05$). After different cooking temperatures and times, breaking strength of duck blood curds was the highest among the three samples($p<0.05$). Observing the microstructure, the duck blood fibrin clot was found to be more dense.

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Table 1. Comparisons of transglutaminase activity from poultry and pig blood

Item	Pig plasma	Chicken plasma	Duck plasma	SEM
Total protein(mg)	2.26[a]	1.96[b]	1.93[b]	0.04
Total activity(units)	1.61[a]	0.79[c]	1.44[b]	0.06
Specific activity(units/mg)	0.71[a]	0.40[b]	0.75[a]	0.03

[a,b,c] Means at the same row without the same superscripts are significantly different($p<0.05$).

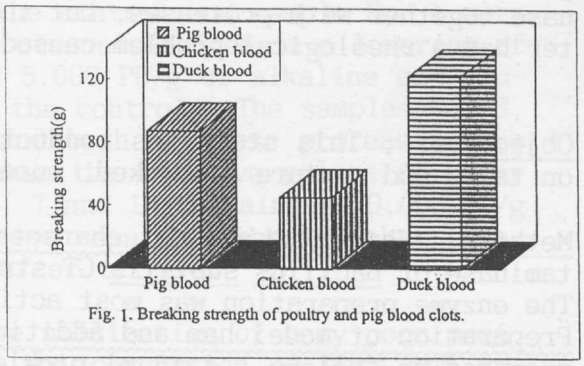

Fig. 1. Breaking strength of poultry and pig blood clots.

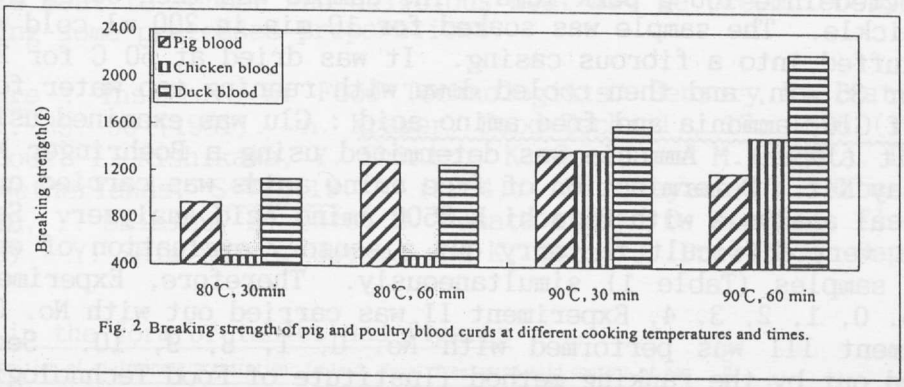

Fig. 2. Breaking strength of pig and poultry blood curds at different cooking temperatures and times.

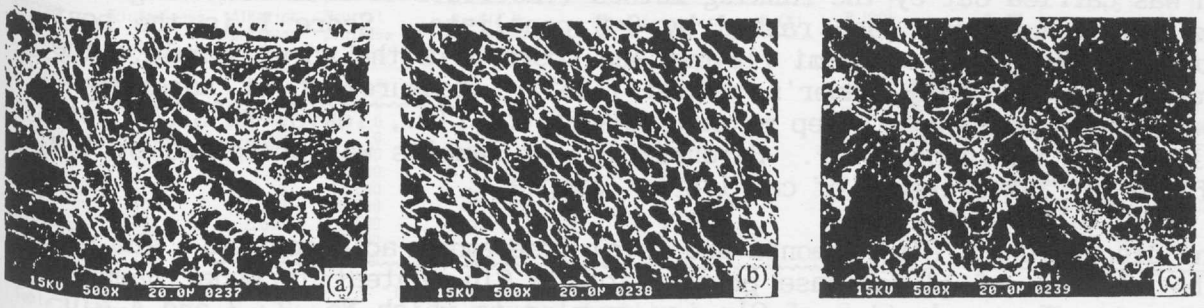

Fig. 3. Scanning electron micrographs of poultry and pig blood clots.
(a)pig blood clot; (b) chicken blood clot; (c) duck blood clot