Comparison on Rheological, Thermal Properties and SDS-PAGE Behavior of Different Protein Sources

Ming-Tsao Chen, Shih-Ming Wei and Deng-Cheng Liu
Department of Animal Science, National Chung Hsing University, 250 Kuo Kuang Road, Taichung, Taiwan R.O.C.

Key words : Non-meat protein , muscle protein , heat-induced gelation , differential scanning calorimetry (DSC).

Introduction

The values of meat products are competitive in meat market, and low cost of products is the most important factor among competitive factors. Addition of non-meat protein or use of low cost raw material is the only one method to carry out this target. Differential scanning calorimetry (DSC) is being used increasingly in the study of thermal denaturation of protein in food such as meat, egg, and soybean protein. It is also a useful technique in the study of the heat denaturation of proteins in foods such as ground meat and paste-state soybean protein which are complex and concentrated protein systems. The purpose of this study was to develop a rapid method (DSC) to identify meat protein or non-meat protein in meat products and promote the quality of meat products and processing technique and to elucidate the relationship between the results of DSC analysis and the rheological properties of heat-induced gels from the samples.

Materials and Methods

Meat proteins (such as chicken breast, beef roast , rabbit roast and tuna) and non-meat proteins (such as soybean protein isolate, sodium caseinate, whey protein, gluten and egg white) were prepared for DSC, rheological properties analysis and SDS-PAGE electrophoresis. The ratio of pork and meat proteins used in this test was 1:1(w/w). The amount of addition of non-meat protein was 2.5% or 5%. A 2.5 % NaCl was added to all samples and minced for 5 min at 4 ℃ for DSC, rheological properties analysis and SDS-PAGE electrophoresis. On the measurements of rheological properties, the meat proteins and their mixtures were heated in a water bath (70 ℃) for 15 min and the non-meat proteins and their mixtures were heated at 70 ℃ and 100 ℃ for 15 min.

Gel strength was measured using a rheometer (Fudoh Rheometer NRM-2010J-CW, Japan) and a differential scanning calorimeter (ULVAC DSC-700, Sinku-Riko, Japan) was used in this study for DSC analysis. The protein fractions were separated with SDS-PAGE as described by Zerifi *et al.*(1992).

Results and Discussion

The gel strength, breaking intension and hardness of pork were significantly different ($P<0.05$) among chicken, beef, rabbit and tuna and pork with these meat proteins (Table 1, Table 2). Among all the samples, chicken had the highest gel strength while beef had the lowest gel strength (Table 1). The gel strength of pork with chicken and tuna increased when compared to pork. Comparing to the DSC thermogram without NaCl, the Tm of all samples with 2.5% NaCl was degraded or disappeared from the DSC thermogram. The gel strength, breaking intension and hardness of pork with non-meat proteins heated at 70 ℃ and 100 ℃ were significantly different ($P<0.05$) from the control (pork)(Table 3, Table 4). Pork with different ratio non-meat proteins had lower gel strength than pork itself whenever cooked at 70 ℃ or 100 ℃. The DSC thermograms of pork with non-meat proteins were similar to a combination of the thermograms of pork protein and non-meat proteins, individually.(Fig.1). Myosin heavy chain and actin had degraded but tropomyosin and troponin-T still existed in the SDS-PAGE patterns when the samples cooked at 100 ℃ for 30 minutes and addition of 2.5% salt. A SDS-PAGE pattern of extracted protein from pork with non-meat proteins heated at 100 ℃ was shown in Fig.2. SDS-PAGE patterns of pork with non-meat proteins were equal to a combination of pork and non-meat proteins separately (Fig.2) and these results were also used to study protein-protein interaction.

Conclusion

The DSC thermograms of meat proteins showed three endothermic peaks and those of non-meat proteins showed one or two endothermic peaks. In the presence of NaCl, the endothermic peaks for meat proteins shifted to lower temperature but for soybean protein shifted to higher temperature. The DSC thermograms of pork with non-meat proteins were similar to a combination of the thermograms of pork protein and non-meat proteins, individually. The thermograms of mixed samples are difficult to explain because their DSC thermogram profiles and heat-induced properties were rather complex. Further investigation is needed to elucidate the relationship between the DSC profiles and heat-induced properties of the mixed samples.

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Table 1. Rheological analysis of different kinds meat pastes cooked at 70℃

kinds	Gel Strength (g)	Breaking Intension (g/cm^2)	Hardness (dyn/cm^2)
Pork	203.50±6.07^c	1036.42±31.05^c	1271300.00± 98578.85^c
Chicken	245.83±6.78^b	1254.82±35.26^b	2116444.44±141348.96^a
Beef	121.40+7.20^d	618.20±36.74^d	773947.50± 51333.07^d
Rabbit	123.60+1.96^d	629.40+10.21^d	750258.75+ 22075.75^d
Tuna	255.17+8.82^a	1300.08+45.05^a	1690800.00± 74541.26^b

n 8

a～d Means within the same column without the same superscript letters are significantly different （P<0.05）

Table 2. Rheological analysis of pork pastes and pork with other meat pastes cooked at 70℃

kinds	Gel Strength (g)	Breaking Intension (g/cm^2)	Hardness (dyn/cm^2)
Pork	203.50±6.07^c	1036.42±31.05^c	1271300.00± 98578.85^c
Pork+Chicken	258.08±7.86^a	1314.75±39.90^a	1615222.22± 80922.46^a
Pork+Beef	156.27±5.06^e	796.33±24.56^e	926294.00± 48953.17^d
Pork+Rabbit	170.75±3.33^d	869.83±16.87^d	988324.00± 24929.56^d
Pork+Tuna	233.42±6.63^b	1189.17±33.88^b	1426600.00± 44485.20^b

n - 8

a～e Means within the same column without the same superscript letters are significantly different （P<0.05）.

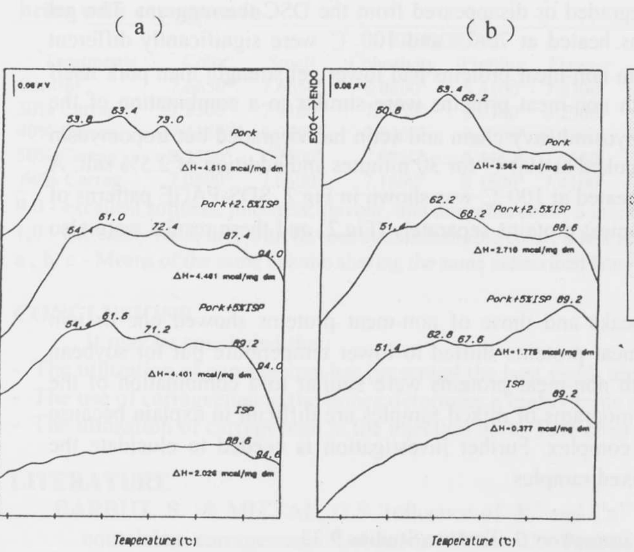


Fig. 1. The DSC thermogram of pork, soy protein isolate and their mixtures (a)with 0 % salt, (b)with 2.5 % salt.

Table 3. Rheological analysis of pork and pork with 2.5% various non-meat proteins cooked at 100℃

kinds	Gel Strength (g)	Breaking Intension (g/cm^2)	Hardness (dyn/cm^2)
Pork	253.92±2.50^a	1293.69±12.70^a	4183125.00±261352.77^a
Pork+2.5% Soy protein isolate	115.00±2.18^e	585.71±11.30^e	2912500.00±158629.72^b
Pork+2.5% Gluten	121.17±2.48^d	617.00±12.68^d	3051400.00+ 95198.27^b
Pork+2.5% Whey protein	151.71+6.53^c	772.53±33.37^c	1517166.67+225724.98^c
Pork+2.5% Na-caseinate	111.15+3.83^f	566.08+19.58^f	661369.00+ 21894.80^c
Pork+2.5% Egg white	209.23±4.97^b	1065.54±25.30^b	1249700.00± 33253.40^d

n=8

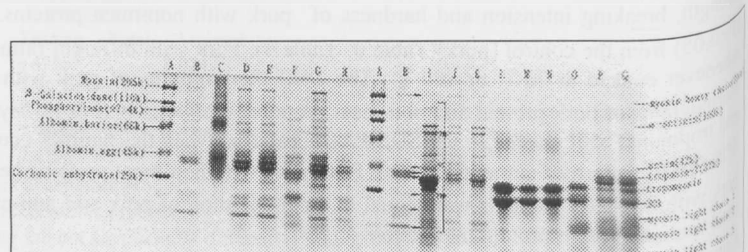
a～f Means within the same column without the same superscript letters are significantly different（P<0.05）.

Table 4. Rheological analysis of pork and pork with 5% various non-meat proteins cooked at 100℃

kinds	Gel Strength (g)	Breaking Intension (g/cm^2)	Hardness (dyn/cm^2)
Pork	253.92±2.50^a	1293.69±12.70^a	4183125.00±261352.77^a
Pork+5% Soy protein isolate	88.17±1.03^d	448.83± 5.15^d	2675750.00±192216.21^b
Pork+5% Gluten	91.46±2.47^d	465.85±12.79^d	963154.00± 98283.53^d
Pork+5% Whey protein	139.60±4.12^c	710.80±21.15^c	876481.11± 50164.61^d
Pork+5% Na-caseinate	72.73±1.74^e	370.09± 9.17^e	425196.36± 10441.15^e
Pork+5% Egg white	187.55±7.46^b	955.18±38.08^b	1193666.67± 53976.85^c

n=8

a～e Means within the same column without the same superscript letters are significantly different（P<0.05）.



A : Standard B : Pork C : Egg White
D : Pork+2.5 % Egg White E : Pork+5 % Egg White
F : Gluten G : Pork+2.5 % Gluten
H : Pork+5 % Gluten I : Soy Protein Isolate
J : Pork+2.5 % Soy Protein Isolate K : Pork+5 % Soy Protein Isolate
L : Na-Caseinate M : Pork+2.5 % Na-Caseinate
N : Pork+5 % Na-Caseinate O : Whey Protein
P : Pork+2.5 % Whey Protein Q : Pork+5 % Whey Protein

Fig. 2. SDS-gel electrophoretogram of pork, non-meat proteins and their mixtures .