4-P31

SARCOPLASMIC PROTEINS MAY DETERMINE THE DEFORMABILITY OF COOKED SAUSAGE BATTER

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Background
It is widely believed that myofibrillar proteins, particularly myosin, are responsible for the bind strength of cooked sausage batter and that sarcoplasmic proteins contribute very little in this process (Samejima *et al.*, 1969). We earlier raised the possibility that different muscle proteins may determine the stress and strain values of cooked sausage batters (Farouk and Swan, 1997). Since then, data from our laboratory led us to suspect that batter shear strain values are more influenced by the amount of sarcoplasmic proteins extracted during batter formation than by the amount of myofibrillar proteins extracted.

Objectives
To investigate the influence of sarcoplasmic protein on the gelling properties of beef as measured by torsion tests.

Methods
Fifty kg of *semitendinosus* muscles were obtained from a meat plant on three processing days. The muscles were divided into 10-kg lots and each was minced through a 10-mm plate. The minced meat from each lot was divided into five 2-kg lots. One lot was not washed and served as the control. The other four lots were mixed with slush ice (1:2 ratio of minced meat to water) for either 15, 30, 45 or 60 minutes, to give four washing times, in a model A200 Hobart mixer fitted with a paddle blade on speed 1 (approx. 60 rpm). The wash water, containing the water-soluble sarcoplasmic proteins, was strained through a four-fold cheese cloth. Samples of the meat and wash water were taken for analysis and the remaining meat was used to make a finely comminuted batter each batter having the same composition in terms of protein, fat and moisture contents.

pH, moisture and protein solubility measurements were as described in Farouk and Swan (1997;1998). Batter processing and measurement of cooked batter torsion stress, strain, and yield were as described in Farouk and Swan (1997). The fat lost from each cooked batter was expressed as a percentage of the weight of the batter before cooking (percent fat loss), as an indication of batter emulsion stability. Rigidity was calculated as the shear stress at failure of the cooked batter divided by the shear strain.

A complete randomized design was used. The experiment was replicated five times, each on a different day.

Results and Discussion
The washing process had to be done without damaging the functional properties of the meat, so any difference observed between the washed and unwashed meat would be due only to the removal of the water soluble proteins. Washing did not affect the pH or the moisture content of the washed samples (Table 1). The protein content of the washed liquid increased with an increase in washing time ($P < 0.01$), indicating the successful removal of water soluble proteins through washing (Table 1).

Washing significantly reduced the amount of soluble sarcoplasmic proteins in the washed mince indicating their successful removal from the mince (Table 1). There was no significant difference in soluble sarcoplasmic proteins between the washed minces, indicating that within the experimental condition of this study, short washing times were sufficient for removing those proteins from the mince samples.

Washing did not affect the total soluble proteins content, indicating that the washing process neither affected the solubility of the muscle proteins nor denatured the muscle proteins (Table 1).

The removal of sarcoplasmic proteins by washing did not affect the torsion stress at failure but did reduce the torsion strain of the cooked batter made from the washed meat ($P < 0.01$) (Table 2). Since the sausage batters contained the same amounts of protein, fat and moisture, the difference between the sausage batters made from washed and control meats could only be due to their differences in sarcoplasmic proteins.

Cook yield ($P < 0.05$) and batter emulsion stability ($P < 0.01$) decreased (% fat loss increased) with washing time, indicating a greater loss of moisture and fat from cooked batter made from meat with a reduced content of sarcoplasmic proteins (Table 2).

Foegeding (1988) suggested that rheological analysis of failure stress and strain can be used to distinguish between filled, mixed and complex gels. The data from this study strongly suggest that sarcoplasmic proteins are important in determining the deformability (strain at failure) of cooked sausage batters. Hamann and MacDonald (1992) reported that cooked batter strain at failure is strongly influenced by protein denaturation. A previous study showed that soluble sarcoplasmic protein content was reduced during a one-month frozen storage of beef (Farouk and Swan, 1998), and another study found that cooked batters made from beef salted before freezing had a higher shear strain than cooked batters made from beef salted after freezing (Farouk and Swan, 1997). Because freezing does not affect the myosin extractability on salting of meat (Brewer *et al.*, 1986), but does affect the extractability of actin and sarcoplasmic proteins (Brewer *et al.*, 1986; Farouk and Swan, 1998), we hypothesise that sarcoplasmic proteins may play an important role in determining the shear strain values of cooked batters.

In this study, the decrease in strain at fracture of cooked sausage batter with the removal of sarcoplasmic proteins indicates that the functional role of sarcoplasmic proteins in the gel matrix is not just that of a filler. Fillers such as carbohydrates tend to increase the shear stress but not the shear strain of gels (Foegeding, 1988). We therefore hypothesise that the functional role of the sarcoplasmic proteins is to form secondary cross links to increase the density of the gel matrix. The primary network formed by myofibrillar proteins determines the cooked sausage batter stress at failure. We propose that some of the sarcoplasmic proteins form cross link with the

myofibrillar proteins, thereby increasing the compactness of the gel matrix, and other sarcoplasmic proteins coagulate and fill the mesh spaces, increasing the deformability of the gel. The cross linking or interaction of the myofibrillar proteins with some of the sarcoplasmic proteins may reduce the strength of the primary gel while at the same time increasing its deformability. In this study, washing increased the concentration of myofibrillar proteins (difference between total soluble and soluble sarcoplasmic proteins). Although the increase in the concentration of myofibrillar proteins did not translate into a significant increase in shear stress of the cooked batter, those values were numerically higher in washed samples compared to controls (Table 2). Cooked batters made from washed meat had a higher rigidity (shear stress/shear strain) than batters made from unwashed controls (Table 2). The higher rigidity of the gels, which also had lower strain values, further supports the hypothesis that sarcoplasmic proteins may be responsible for gel deformability and that they may be acting as both cross linkers and fillers in the same gel matrix. Based on these assumptions, cooked sausage batter of the kind used in this study may be termed a filled complex gel (Foegeding, 1988). The increase in the density of the gel matrix or cross links created by the sarcoplasmic proteins may also influence the water and fat retention capacity of cooked batters. In this study, cooked batter yield and emulsion stability both decreased with the removal of sarcoplasmic proteins (Table 2).

The scanning and transmission electron micrographs of cooked batter (not shown) from washed samples indicated the batters were denser than those from unwashed samples.

Conclusions

The results of this study suggest that sarcoplasmic proteins are important in determining the deformability of cooked sausage batter.

Pertinent Literature

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Acknowledgements

This research was funded by Meat New Zealand.

Table 1. Effect of washing on composition and protein solubility of minced beef

Wash time, min	pH	Moisture, %	TSP, %	SSP, %	% protein in wash water
Unwashed	5.67	74.7	18.5	7.0	na
15	5.68	75.4	19.2	3.7	2.2
30	5.68	74.6	18.8	4.6	2.4
45	5.67	74.7	19.9	3.4	2.7
60	5.67	74.9	18.2	3.6	3.3
P level	NS	NS	NS	< 0.05	< 0.01

na = not applicable; TSP = Total soluble proteins; SSP = Soluble sarcoplasmic protein; *P* = Level of significance

Table 2. Effect of sarcoplasmic protein content on torsion stress and strain at failure, cook yield and emulsion stability

Wash time, min	Stress, kPa	Strain	Rigidity, kPa	Cook yield, %	Fat loss, %
Unwashed	40.7	1.52	26.8	87.7	0.33
15	42.7	1.31	35.6	83.6	0.48
30	42.4	1.34	31.6	82.1	0.75
45	41.4	1.36	30.4	81.8	0.82
60	43.8	1.36	32.2	81.9	0.94
P level	NS	< 0.01	< 0.05	< 0.05	< 0.01

For abbreviations, see Table 1.