BINDING AND TEXTURAL PROPERTIES OF PORK MEAT GELS AS AFFECTED BY MICROBIAL TRANSGLUTAMINASE AND NON-MEAT PROTEINS

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Background

Non-meat ingredients derived from a variety of plant and animal sources are routinely used in the manufacture of comminuted products because of their functional properties including emulsification, water- and fat binding capacity, improvement of texture and appearance. As the demand for food products of high quality increase, it will also become more important to be able to modify the properties of food proteins. Non-meat proteins are often used as alternative gelling agents in comminuted meat products to enhance the yield and texture by improving water binding properties. However, non meat proteins may also impose some negative effects or interfere with the gelation of the myofibrillar proteins. The possibility of modification of functional properties of non-muscle proteins would contribute to improved utilization and processing qualities of these ingredients in meat products. In recent years, the potential of exogenous transglutaminase (MTG) in catalyzing cross-linking of food proteins and modifying the functional properties of these proteins has been demonstrated. Transglutaminase therefore has been proposed as a useful tool for improvement of rheological and binding properties of food proteins. Although effects of transglutaminase on texture are well documented for raw (not cooked), restructured meats (Nielsen et al., 1995; Kuraishi et al., 1997), little information is available on the effects that MTG has on textural characteristics of cooked meat emulsions. Therefore, the present study was undertaken to determine whether microbial transglutaminase would have a synergistic effect with NMP to improve bind and textural properties in cooked pork homogenates.

Objective

The objective of this study was to determine the combined effect of incorporation of four non-muscle proteins (blood plasma, sodium caseinate, soy isolate, gelatin) at 2% levels on hydration, textural, and color characteristics of meat gels processed without or with 0.6% microbial transglutaminase preparation.

Methods

A completely randomized design with a 2x5 complete factorial arrangement of treatments was used. The main effects investigated were: MTG level (0 and 0.6%) and type of non-muscle protein (2%) addition (C- control, SC-sodium caseinate, BP-blood plasma, SI-soy isolate, G-gelatin). Spray dried porcine blood plasma (VEPRO 75 PSC) was obtained from VEOS NV, Belgium. Soya isolate (SUPRO 595) was a commercial product from Protein Technology Int., USA. Sodium caseinate was a commercial product from PHZ SM „Lacpol", Poland. Gelatin was donated by "GELPOL", Poland. Microbial transglutaminase (MTG), (Ajinomoto, Barentz, Poland) was a mixture containing 99% maltodextrin and 1% microbial transglutaminase (activity of approx. 100 units/g). The enzyme concentration is reported in the present study as the commercial concentration. Non-meat proteins were hydrated with chilled brine for 30 min prior to addition to meat ingredients.

Fresh post-rigor pork meat (*Semimembranosus* muscles) was purchased from a local market. The pork was trimmed of visible fat and connective tissue, then ground in a laboratory grinder through a plate with 3 mm diameter orifices. The ground meat was portioned, vacuum-packaged and frozen at -22°C until product formulation. Before processing, the meat was tempered at 4°C for 15 hours. Meat protein content was adjusted to a constant level of 8% in all formulations by manipulating moisture level with shredded ice. Treatments (200 g each) were prepared by mixing ground meat and non-meat ingredients for 15 s using a BUCHI „MIXER B-400" (9000 rev./min). Concentrations of sodium chloride, sodium nitrite and sodium ascorbate in all formulations were set at constant levels of 2.0%, 0.01% and 0.25%, respectively. The final temperature of the homogenates never exceeded 7°C. Immediately after homogenate preparation, batters were stuffed into cylindrical plastic tubes (30 mm x 115 mm), covered with plastic film and refrigerated overnight in a walk-in cold room at 5°C. The homogenate samples were then heated isothermally in a water bath at 75°C to a final internal temperature of 72°C and thereafter cooled in ice water until a core temperature of 20°C was reached in the core, and stored at 4°C until use. The variables measured on pork gels included: pH, cook yield (% of the raw stuffed weight) and expressible moisture (EM). Instrumental texture profile analysis (TPA) was performed on pork gels using a STEVENS-QTS 25 texture analyzer. Five center cores (25 mm in diameter, 15 mm height) of gel samples were compressed twice to 25% of their original height at a constant cross-head speed of 60 mm/min. Color of the meat gels was measured using a MINOLTA CR 200b spectrocolorimeter and expressed as CIE L* (lightness), a* (redness) and b* (yellowness) values. Data were analyzed as a 2x5 factorial design with two MTG levels (0 and 0.6%) and five ingredient treatments (C, SC, BP, SI, G) as main factors. The Least Significant Difference test at $p=0.05$ was used to determine differences between treatment means.

Results and discussion

The pH values of the meat gels ranged from 5.87 to 6.26 (average pH of 6.01). The highest pH values were reported for the gels containing SC and BP ($p<0.001$), likely due to their neutral pH (pH of 1% solution was 6.8 and 6.9 respectively). MTG addition had no effect on pH of the cooked products.

Generally, regardless of MTG addition, the non-muscle proteins (NMP) improved the hydration properties of gels, resulting in significantly higher cook yield as compared to samples containing only 8% muscle proteins. The highest cooking yields were observed in the gels with SC and BP addition. Binding properties were also markedly improved by transglutaminase, but the effect of its addition was strongly dependent on NMP type. The significant improvements occurred only for treatments processed with sodium caseinate, gelatin and without NMP addition whereas MTG had no effect on hydration properties of gels processed with blood plasma or soy isolate (Fig. 1).

Both MTG preparation and NMP had significant effects on EM from the pork gels. Generally, addition of all tested ingredients to the pork homogenates decreased the percentage of water loss from gels after pressing the gel samples, indicating that they improved water retention of meat gels (Fig. 2). However, the effect of MTG on water retention was influenced by type of protein, as shown by the interactive effect ($P<0.05$) between the two variables. MTG decreased the percentage of water loss from gel samples but only in the control gels (without NMP) and produced with gelatin addition. Except for the gelatin treatment without MTG, all other NMP improved water retention of gels as compared to those without their addition. However no significant differences among them were detected.

Table 1 summarizes the TPA parameters for the experimental gels as affected by test ingredients. The effect of MTG on textural properties of gels varied with type of NMP used as indicated by MTG x NMP interactions ($P<0.05$). Of the NMP used, only addition of soy protein contributed to improved hardness of meat gels processed without MTG. The greatest improvement of gel strength (by 80%) due to MTG addition was observed for treatments processed with sodium caseinate. Our results support the findings of Kuraishi et al. (1997), who evaluated a microbial transglutaminase (MTGase) for its ability to introduce covalent crosslinks between meat protein molecules and some food proteins. They found that sodium caseinate appeared to be a superior substrate for the crosslinking to meat proteins than soy protein, whey protein, or gelatin. Nonaka et al. (1992) reported that the increased breaking strength and hardness of sodium caseinate gels treated with a microbial transglutaminase was the result of enzymatic polymerization. MTG also increased hardness of the control gels and those containing blood plasma but had no effect on strength of the gels produced with soy protein isolate and gelatin.

Regardless of MTG presence, NMP addition significantly decreased cohesiveness of gels. MTG treatment resulted in a slight increase of cohesiveness of the gels produced with SC, BP and G. However, overall it was not successful to restore cohesiveness of gels containing non-muscle proteins to that of the 8% control gels. With the exception of the treatments with addition of gelatin to the meat system, which significantly decreased springiness, none of the other NMPs affected the elastic characteristics of the gels.

NMP caused significant alterations in colour of gels (data not shown). Regardless of MTG level, NMP generally lightened colour (lower redness and higher lightness values). No significant effect of MTG addition on the gel colour parameters (L*, a*, b*) was observed.

Conclusions

Addition of SC and BP most favourably affected hydration properties and thermal stability, yielding lower cooking loss and EM for pork gels. Interactions between non-muscle proteins and MTG were observed. For example, improvement of gel strength by addition of MTG was observed for treatments containing sodium caseinate and blood plasma but not gelatin nor soy isolate. Of the four proteins tested SC was found to be a superior substrate for MTG in enhancing textural properties of gelled meat system. None of the tested ingredients was able to yield gel cohesiveness equivalent to the control containing 8% muscle proteins.

Results of this study indicate a potential for using MTG to improve or modify the functional and rheological properties of some food proteins in comminuted meat products. Transglutaminase treatment therefore provides new opportunities for extending the range of their functional properties in meat systems.

Pertinent literature

Kuraishi, C., Sakamoto, J., Yamazaki, K., Susa, Y., Kuhara, C., Soeda, T. (1997) Production of restructured meat using microbial transglutaminase without salt or cooking. *Journal of Food Science, 62,* 488-490, 515.

Nielsen, G.S., Petersen, B.R., Moller, A.J. (1995a). Impact of salt, phosphate and temperature on the effect of a transglutaminase (F XIIIa) on the texture of restructured meat. *Meat Science, 41,* 293-299.

Nonaka, M., Sakamoto, H., Toiguchi, S., Kawajiri, H., Soeda, T., Motoki, M. 1992. Sodium caseinate and skim milk gels formed by incubation with microbial transglutaminase. *Journal of Food Science*, 57, 1214-1218, 1241.

Fig. 1: Effect of NMP and MTG on cook yield of pork gels

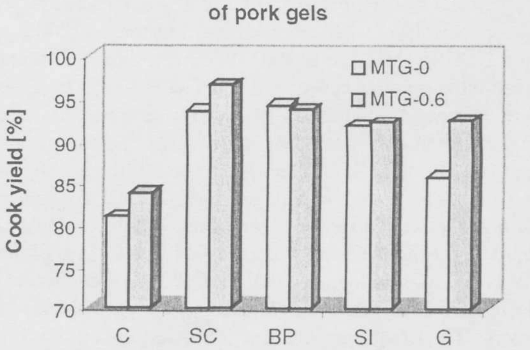

Fig. 2: Effect of NMP and MTG on expressible moisture from pork gels

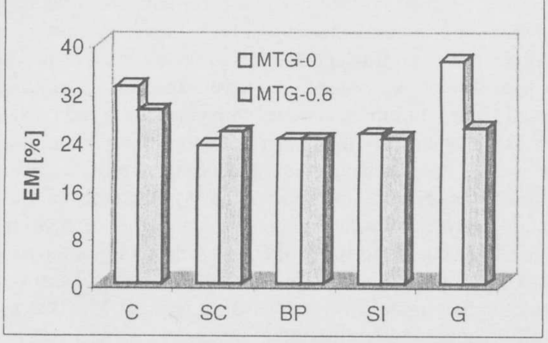

Table 1. TPA parameters of pork gels as influenced by added ingredients.

Treatments	Hardness [N]		Cohesiveness		Springiness [mm]		Chewiness [N*mm]	
	MTG level [%]		MTG level [%]		MTG level [%]		MTG level [%]	
	0	0.6	0	0.6	0	0.6	0	0.6
C	18.8^{b1}	26.8^{b2}	0.50^{a}	0.46^{a}	9.0^{a}	9.4	85.2^{b1}	114.3^{b2}
SC	19.9^{b1}	36.4^{a2}	0.32^{bc1}	0.38^{b2}	9.7^{a}	10.3	60.8^{b1}	143.7^{a2}
BP	18.2^{b1}	26.9^{b2}	0.29^{bc1}	0.37^{b2}	8.4^{a1}	10.0^{2}	45.3^{bc1}	98.6^{b2}
SI	34.9^{a}	39.5^{a}	0.36^{b}	0.37^{b}	10.1^{a}	10.0	128.0^{a}	144.4^{a}
G	18.2^{b}	20.1^{c}	0.28^{c1}	0.36^{b2}	7.0^{b1}	9.0^{2}	35.2^{c1}	64.1^{c2}

Means in the same column with different letters or with different numbers in the same row (within each parameter) are significantly different ($p<0.05$)