SOME CHARACTERISTICS OF EXUDATES FORMED DURING SIMULTANEOUS CURING AND MASSAGING OF PRE-RIGOR AND POST-RIGOR PORK MEAT

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Introduction

Binding of meat pieces in restructured and formed or other comminuted meat products results from thermally gelation of salt-soluble myofibrillar proteins (MacFarlane et al., 1977; Siegel and Schmidt, 1979; Samejima et al., 1985). These proteins can vary in composition, depending on concentration of NaCl or ionic strength and pH (Van Den Oord and Wesdorp, 1978; Foegeding, 1987), as well as on rigor states of postmortem muscles (Johnson and Henrickson, 1970; Samejima et al., 1992).

The kind, and specially the quantitative ratio of individual proteins extracted during simultaneous curing and massaging (SCM) or tumbling, is of special significance for the quality of cooked canned ham and similar products. Among myofibrillar proteins, the most important ones are myosin and actin because the rate of binding of meat pieces after thermal processing, first of all, depends on them (Siegel et al., 1978; Mandigo, 1985; Samejima et al., 1988). In general, more investigations have shown that myosin by itself forms excellent gels, and actin has poor gelation properties but has a synergistic or antagonistic effect on myosin gelation, depending on the myosin/actin ratio (Yasui et at., 1982; Morita et al., 1987; Yamamoto et al., 1988).

In the exudate formed during SCM of post-rigor (cooled) pork, the total protein content is increased (Siegel and Schmidt, 1979). At the same time, the content of soluble proteins is increased, whereby their participation decreases with the increase of total protein content. At the beginning of the process, soluble proteins are primarilly transferred to the exudate due to the effect of curing salts, and during further phases the content of other proteins is also increased due to mechanical action (Stefanovic, 1980).

In the course of the first 8 hours of SCM of post-rigor meat, the content of proteins in the exudate is continually increased, but the ratio of individual fractions of myofibrillar proteins (myosin, actin, tropomyosin, C-protein and a-actinin) is not essentially changed (Theno, 1977). Massaging itself of post-rigor meat does not influence more considerably the quantity ratio of individual muscle proteins in the exudate. However, in the initial phase of SCM, by using minimum quantities of sodium chloride, the participation of myosin and actin in the exudate is considerably increased and that of tropomyosin decreased. By adding phosphates and higher quantities of sodium chloride, the participation of myosin and actin in the exudate (during SCM) is decreased, simultaneously with the liberation of other muscle proteins as well, whereas the participation of C-protein and a-actinin is not changed more essentially (Siegel et al., 1978).

Since the obtained results are not in complete agreement and as there are not more detailed data on the exudate proteins when SCM of pre-rigor meat is in question, the aim of this work was to carry out comparative examination of the content and the solubility of individual proteins of the exudate formed during SCM of pre-rigor and post-rigor pork.

Materials and methods

Ham muscles of white meaty hogs, 6 to 8 months old and 90 to 100 kg in liveweight, were used for the examinations. Cooled (2 to 4° C) curing brine (composition: water 72,25%, sodium chloride 18,30%, dextrose 6,0%, polyphosphate-Tari P22 3,0%, sodium nitrite 0,10% and sodium ascorbate 0,35%) was injected in the quantity of 16% by using pickle-injector with 120 needles (Ben Langen, Holland). Pre-rigor (90 to 120 min p. m.) and post-rigor meat (24 h p.m.) was used. SCM was performed in the massaging vat (Fekro-Gorenje, Slovenia) of 800 l in volume, with three rotating flappers square in form which rotated at the speed of 14 rpm during 16 hours (program: alternatively rotation 10 min. and 20 min. rest).

The exudate formed after 0.5, 1, 3, 5, 7, 9, 12, 14 and 16 hours of SCM of meat was filtered through a metal sieve (Prülsiev 1,0 TGL 4188) of 1 mm openings and then used for further examinations. For the extraction of sarcoplasm proteins from the exudate, 0,03 mol/l phosphate buffer was used and for myofibrillar proteins - 0,1 mol/l phosphate buffer with 1,1 mol/l KJ, cooled at 2 to 4° C and with pH adjusted to 7,4 (Helander, 1957; Alvi, 1980). The content of proteins was determined by the Kjeldahl nitrogen procedure (AOAC, 1990), separation of individual fractions of soluble proteins of the exudate at 0,1 mol/l phosphate buffer with 1,1 mol/l KJ was performed by sodium dodecyl sulfate-polyacrylamide gel electrophoresis (SDS-PAGE), and reading by densitometer (Varian Superskan 3) at the wavelength of 560 nm (Davis, 1964; Ornstein, 1964). Difference between means was determined by the Student's t-test.

Results and discussion

Our previous examinations have shown that the content of total proteins in the exudate during SCM of both pre-rigor and post-rigor pork is increased, being higher ($p < 0,05$) in the exudate of post-rigor meat only in the initial phase (up to the third hour) of the process duration (Kočovski, 1990).

A relatively small quantity of extracted sarcoplasm proteins and the established insignificant differences and deviations during SCM of pre-rigor and post-rigor meat (Fig. 1) are the result of high salt concentration in the curing brine which disables their extraction (Goll et al., 1977; Hamm, 1981; Kijowski, 1984).

The quantity of myofibrillar proteins in the exudate is increased during SCM of pre-rigor and post-rigor meat (Fig. 2). Up to the 14th hour, it is higher ($p < 0,01$) in the exudate of post-rigor SCM meat, but these differences are lost in the final stage. The established differences are probably the result of higher leakiness of the sarcolem of muscle cells of post-rigor meat due to the appearance of postmortem changes and structural damages of the tissue (Siegel et al., 1977; Cassidy et al., 1978; Cerrella and Massaldi, 1978; Theno et al., 1978; Reit et al., 1978; Belousov et al., 1980; Velinov et al., 1987), better extraction of proteins at lower temperatures (Gillett et al., 1977; Grabovska and Hamm, 1978; Hoogenkamp, 1986; Ravasini and Van Griethuysen, 1992) and higher structural damages due to massaging.

Definite differences in the participation of most significant myofibrillar proteins in the exudate formed during SCM of pre-rigor (Table 1) and post-rigor meat (Table 2) were established by electrophoretic examinations. The myosin-heavy chains (MW $20x10^4$) and actin (MW $42x10^3$) contents increased during SCM of pre-rigor meat, whereas they are not changed significantly up to the 9th hour in post-rigor meat. The marked differences between exudates regarding the content of these proteins decrease significantly after the 7th, that is, after the 9th hour of SCM.Considerably higher content of myosin and actin in the exudate during the first half of the SCM process of post-rigor meat points to their more rapid dissolution and easier separation through the "open" meat structure. The established participation of actin and myosin in the exudate of SCM meat after rigor is in agreement with the statements of Theno (1977).The increase of the content of myosin and actin fractions during SCM of pre-rigor meat is the result of more and more voluminous destruction of the muscle tissue and the effect of sodium chloride and phosphates.

The presence of protein fraction MW $36x10^3$ is considerably higher in the exudate during the first nine hours of SCM of pre-rigor meat, then it decreases and reaches the same value as that of post-rigor meat. The reason for that should be looked for in the possible activity of enzymatic systems, whereby troponin T, titin, nebulin and dezmin are desintegrated simultaneously with the increase of the content of polypeptides of lower molecular weight, specially those with MW of about 30 000 dalton (Orcut and Dutson, 1985; Bandman and Zdanis, 1988; Calkins and Seideman, 1988; Buts et al., 1989; Hwan and Bandman, 1989).

Conclusion

1. Extraction of individual protein fractions from pork during the first half of the SCM process depends on the rate of postmortem changes, temperature and the rate of mechanical damage of the muscle tissue structure.
2. Participation of the most important myofibrillar proteins in the exudate of SCM pre-rigor and post-rigor meat is equalised by the end of the process.
3. More rapid extraction of proteins during SCM of pre-rigor meat could be accomplished by lowering the temperature and by more intensive mechanical treatment before and/or after the curing brine injection.

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Fig. 1. Protein solubility (% of total exudate protein) at 0,03 mol/l phosphate buffer

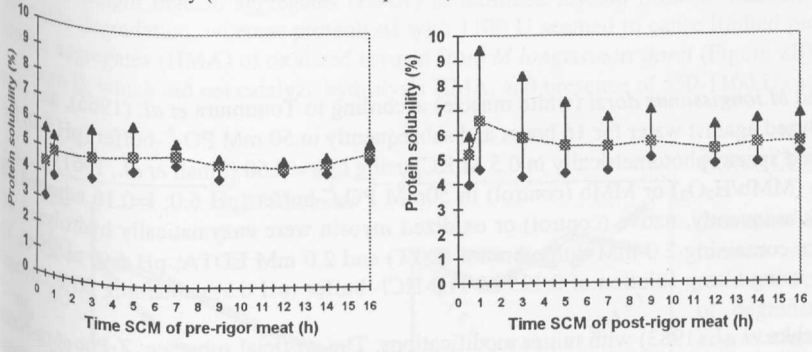
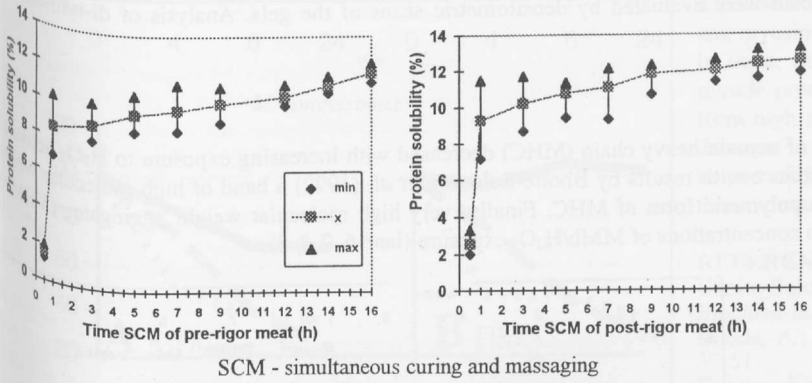


Fig. 2. Protein solubility (% total exudate protein) at 0,1 mol/l phosphate buffer with 1,1 mol/l KJ



SCM - simultaneous curing and massaging

Tab 1. Content of soluble* proteins in exudate formed during SCM of pre-rigor meat (n=6)

Protein fractions MW	Time SCM (h)					
	1	3	5	7	9	12
	relative share of proteins (%)					
20.10^4	5,15	6,01	6,11	13,14	15,50	22,86
10.10^4	21,57	21,12	16,15	17,75	20,32	20,50
42.10^3	9,58	10,28	10,36	10,43	14,31	15,82
36.10^3	33,05	25,38	23,13	19,69	16,06	10,75
30.10^3	8,49	12,58	16,12	14,17	12,52	9,76
25.10^3	14,96	18,03	20,44	16,59	13,01	12,02
$15\text{-}20.10^3$	7,20	6,61	7,69	8,25	8,28	8,30

* at 0,1 mol/l phosphate buffer with 1,1 mol/l KJ

Tab 2. Content of soluble* proteins in exudate formed during SCM of post-rigor meat (n=6)

Protein fractions MW	Time SCM (h)					
	1	3	5	7	9	12
	relative share of proteins (%)					
20.10^4	17,28	19,11	19,02	18,09	19,95	24,12
10.10^4	19,05	21,37	20,35	18,33	21,61	21,32
42.10^3	16,05	14,91	14,12	15,97	16,94	20,25
36.10^3	14,58	13,84	13,06	14,12	11,85	10,44
30.10^3	11,67	12,68	12,41	9,95	11,95	8,67
25.10^3	12,25	11,16	12,94	15,76	9,93	8,13
$15\text{-}20.10^3$	9,12	6,94	8,10	7,78	7,77	7,07

* at 0,1 mol/l phosphate buffer with 1,1 mol/l KJ

MW- molecular weight