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THE EFFECT OF COLLAGEN COMMINUTION ON THE RHEOLOGICAL PROPERTIES OF SAUSAGES

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Introduction

The sausage emulsions for frankfurters and bologna contain much connective tissue. It is assumed that the collagen of the connective tissues participates, after partial gelatinization, in binding of water and in forming the rheological properties of the product. The exact mechanism of interaction of collagen with the other constituents of the sausage emulsion is not known in details. If something in the manufacturing process goes wrong, fat and gelatin deposits or grainy structure may appear and the elasticity of the product may be low. The results of several investigations regarding the role of collagen in the formation of texture in emulsion-type sausages are controversial (1,2,3). If collagen does not influence the binding properties of other meat proteins and participates in the formation of the desirable texture only by binding water and fat by itself, any treatments enhancing its water retention properties, e.g. by increasing the degree of comminution, shoud decrease the cooking loss and improve the texture of the sausages.

Materials and methods

Lard and fresh beef meat from old animals, low in connective tissue were used in the experiments. The tendons and fat were carved out of the meat as carefully as possible. The meat and fat were ground separately in a meat grinder with a plate of 5 mm mesh diameter and frozen at -18°C. The meat contained 23 % crude protein and 2 % fat. The collagen was isolated from the connective tissue sheats surrounding the beef round. The sheats, after very thorough mechanical defatting, were ground in a frozen state in a meat grinder through a 5 mm mesh plate. The accompaning noncollagenous constituents were extracted with distilled water followed by 10 % NaCl solution, according to the procedure described earlier (4). The collagen: water mixture (1:1) was frozen and ground again through plates of 3, 2, and 1 mm mesh diameter and the excess of water was separated by centrifuging. In order to obtain a finer comminution the collagen preparation was mixed with 0.05 M HCl solution (1:4) and after 24 hours run through a colloid mill. The fine fibers formed after neutralization were separated in a centrifuge.

The sausage emulsion contained 11 % crude protein, 11 % or 30 % fat, and 2 % NaCl. Collagen, when used, replaced 20 % of meat proteins. The material was chopped in a silent cutter during 30 minutes, the fat was added after 5 minutes from start. The temperature of the mixture did not exceed 16°C. The emulsions were characterized by viscosity determined in a rotary viscometer Rheotest 2 at a shear rate of 5,4 s^{-1}, stuffed in 35 mm collagen casings, cooked 30 min. in water at 85°C, and cooled under running tape water to about 15°C. The collagen and meat dispersions were heated in water at 85°C to reach the internal temperature from 30 to 80°C.

The products were characterized by the yield, free and expressible drip, and the rheological properties.

The Kjeldahl protein was determined using the factor 6.25 for meat protein and 5.55 for collagen. The water holding capacity (expressible drip) was determined after Shults and Wierbicki (5), and the free drip according to Bakunc and Bartanjan (6). The rheological properties of the cooked products were characterized by the yield limit and elasticity. The yield limit of 15 mm thick slices was measured in a penetrometer with a flat plunger, 8 mm in diameter and the elasticity with a flat punch, 40 mm in diameter.

Results

The influence of the degree of comminution of fresh, uncooked collagen on its water holding capacity after heating depends on some unspecified properties of the collagen. In one batch of the collagen preparation merely repeating the mincing through a 3 mm mesh plate increased the water holding capacity at 85°C by about 40% (Fig.1), while in an other batch the second mincing, through a smaller diameter mesh (1 mm) did not change the hydration and only comminution in a colloid grinder doubled the water holding capacity (Fig.2) . The collagen minced in the ordinary grinder was grainy in structure while that comminuted in the colloid mill was in form of very

Fig.1 The influence of heating at 85°C on the water holding capacity of collagen ground through a 3 mm plate

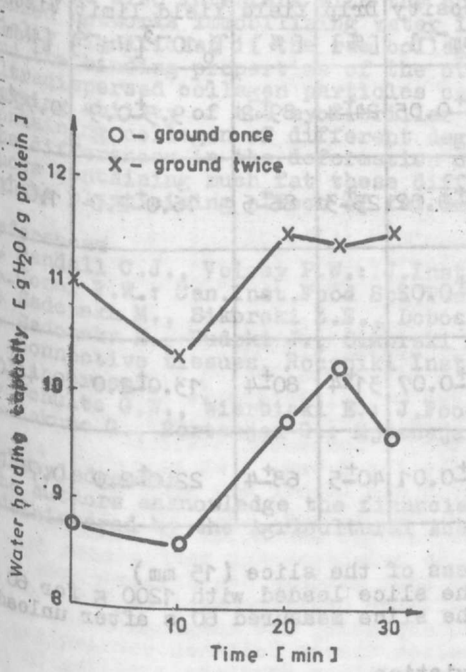

Fig.2 The influence of temperature on the water holding capacity of meat homogenate and collagen

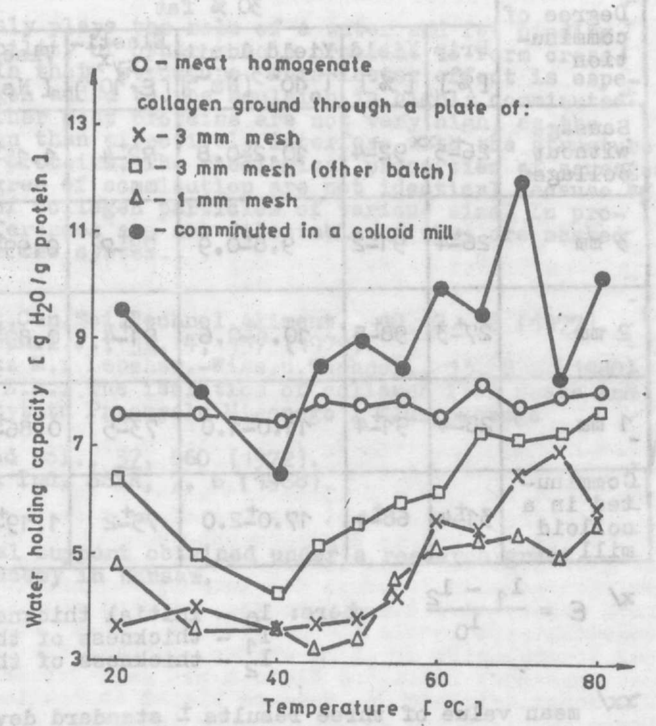

Fig.3 The influence of temperature of sausage emulsions on the expresible drip

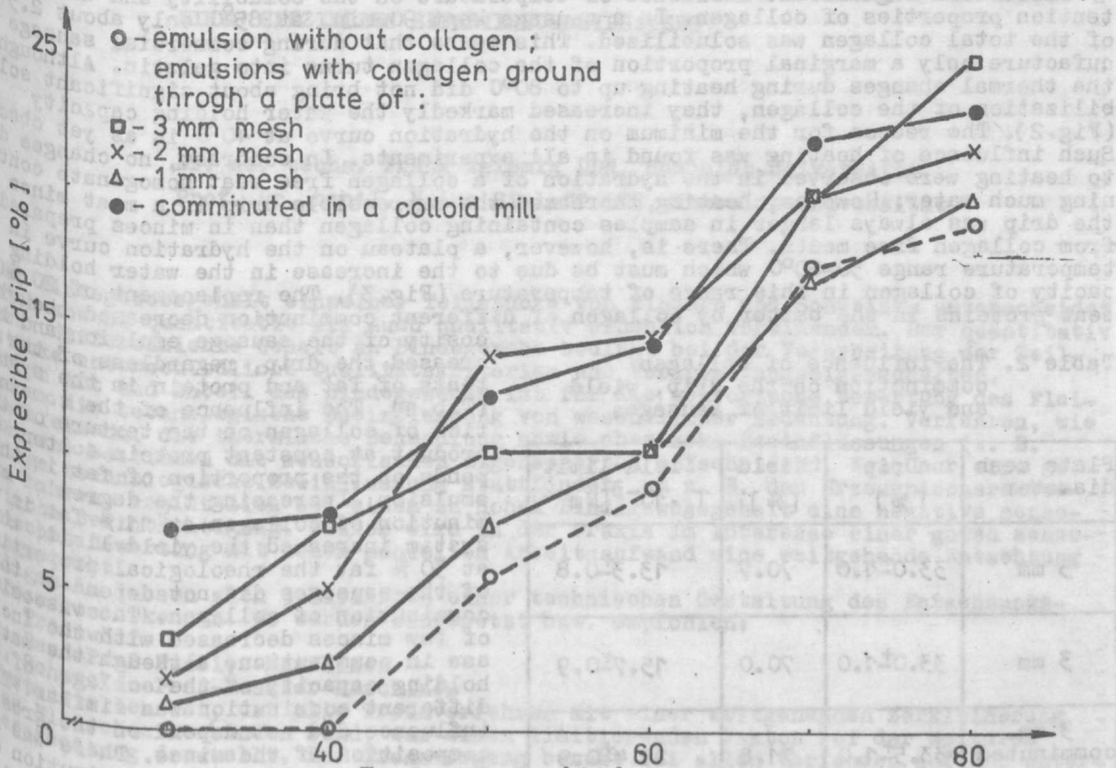

Table 1. The effect of collagen comminution on the properties of sausages containing 30 and 11 % fat

Degree of comminution	30 % fat					11 % fat			
	Drip [%]	Yield [%]	Yield limit $\tau_o \cdot 10^{-3}$ [Nm^{-2}]	Elasticity^{x} [$\varepsilon \cdot 10^3$]	Viscosity [Nsm^{-2}]	Drip [%]	Yield [%]	Yield limit $\tau_o \cdot 10^{-3}$ [Nm^{-2}]	Viscosity [Nsm^{-2}]
Sausage without collagen	26±5^{xx}	92±4	10.2±0.8	72±4	1.15±0.05	24±4	89±2	9.5±0.9	0.72±0.04
3 mm	26±4	91±2	9.8±0.9	78±7	0.99±0.02	25±3	86±5	16.0±2.0	1.00±0.07
2 mm	27±3	98±5	10.1±0.6	91±4	0.89±0.02	–	–	–	–
1 mm	28±4	91±4	11.0±1.0	73±5	0.86±0.07	31±4	80±4	13.0±2.0	0.46±0.00
Comminuted in a colloid mill	31±4	68±4	17.0±2.0	75±2	1.19±0.01	40±5	68±4	22.0±2.0	0.76±0.06

x/ $\varepsilon = \frac{l_1 - l_2}{l_o}$ where: l_o – initial thickness of the slice (15 mm)
l_1 – thickness of the slice loaded with 1200 g for 60 s
l_2 – thickness of the slice measured 60 s after unloading

xx/ mean value of three results ± standard deviation

fine fibers.

There is a significant influence of temperature on the solubility and water retention properties of collagen. In a sausage kept 90 min. at 85°C only about 2.5 % of the total collagen was solubilized. This means that during commercial sausage manufacture only a marginal proportion of the collagen turns into gelatin. Although the thermal changes during heating up to 80°C did not bring about significant solubilization of the collagen, they increased markedly the water holding capacity (Fig.2). The reason for the minimum on the hydration curve at 40°C is as yet obscure. Such influence of heating was found in all experiments. In contrast, no changes due to heating were observed in the hydration of a collagen free meat homogenate containing much water. However, heating increased the expressible drip in a meat mince and the drip was always larger in samples containing collagen than in minces prepared from collagen free meats. There is, however, a plateau on the hydration curve in the temperature range 50-60°C which must be due to the increase in the water holding capacity of collagen in this range of temperature (Fig.3). The replacement of 20 % of meat proteins in the batter by collagen of different comminution decreased the viscosity of the sausage emulsion and increased the drip, regardless of the contents of fat and protein in the system (Tab.1). The influence of the comminution of collagen on the texture of the product at constant protein content depends on the proportion of fat in the emulsion. Increasing the degree of comminution of collagen at 11 % fat in the system increased the yield limit, while at 30 % fat the rheological properties of the sausages did not depend on the comminution of collagen. The viscosity of raw minces decreased with the increase in comminution, although the water holding capacity of the collagen of different comminution was similar. This influence did not depend on the gross composition of the mince. There was no correlation between the comminution of collagen and the cooking loss and yield

Table 2. The influence of collagen comminution on the drip, yield and yield limit of sausages

Plate mesh diameter	Drip [%]	Yield [%]	Yield limit $\tau_o \cdot 10^{-3}$ [Nm^{-2}]
5 mm	33.0±1.0	70.7	13.3±0.8
3 mm	33.0±1.0	70.0	15.7±0.9
3 mm comminuted twice	33.5±1.0	71.8	23.4±0.9

f the sausage (Tab.2). An increase in the water holding capacity of collagen by about 40 %, caused by additional comminution, was accompanied by 50 % higher yield limit of the product.

Conclusions

Collagen in sausage emulsions not only plays the role of a water and fat binding agent but also interfers with the ability of other muscle proteins to form cross-linked networks immobilizing water in their structure. This latter effect is especially significant if the raw collagen added to the emulsion is highly comminuted and the binding properties of the other meat proteins are not very high, as the ultradispersed collagen particles can than effectively interfere with the structure forming ability of the myofibrillar proteins. The rheological properties of sausages containing collagen of different degree of comminution are not identical because of the differences in the deformation of collagen particles of various size. In products containing much fat these differences are not detectable as they are masked by the plasticizing effect of fat in the system.

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