EFFECTS OF SOYPROTEINS ON TECHNOLOGICAL AND MORPHOLOGICAL PROPERTIES OF BOLOGNA TYPE SAUSAGE

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Fine comminuted and heated meat products such as Bologna type sausage depend on the development of an efficient protein matrix within the product. The myofibrillar meat proteins play a decisive role in this process. As components and quantity of meat considerably vary depending on individual sausage recipe, in practice one is confronted with different binding capacities of the used meat. Sausages with reduced binding capacity were therefore given additives such as water and fat binding elements and protein substitutes like plasmaprotein, Na-caseinate and soy protein. Experience has shown that soy protein is the appropriate additive to Bologna type sausage (SOFOS and ALLEN, 1977; SOFOS et al., 1977; STUHLBERGER, 1988).

The use of soy protein as an additive to meat products has become increasingly common throughout the world. And also the assortment of offered soy protein products is continually expanding. There is a variety not only among the different soy protein products (soy concentrate and soy isolate) but also among the functional properties of one and the same type of soy protein depending on, in particular, the mode of extraction. Exactly these functional properties play an important role in view of the optimum use and the production warranty and therefore they should be tested in accordance with the model system (under laboratory conditions) prior to use.

The aim of the present study was to evaluate the physicochemical properties of different soy proteins and to test their technological effect on the production of fine comminuted sausage. Further morphological findings should be gained about the mechanism of matrix development and fat binding of meat and soy protein components.

Material and Methods

Texture and components of the raw material were maintained as constant as possible throughout all tests. The basic components of Bologna type sausage consisted of 30 % pork, 15 % beef, 25 % pork fat and 30 % ice. Additives were 20 g sodium chloride or curing salt respectively, 4 g mixed spices, 0.3 g Na-ascorbat/1 kg meat-fat mixture. In those cases where phosphate (di-phosphate, pH 6.9) was added the ratio was 2 g phosphate/1 kg meat-fat mixture. For a better standardization the lean meat and the fatty tissue were passed separately through the meat grinder (3 mm disc). The thus treated lean meat and fatty tissue were cooled at 0° to 2°C for 24 hours. After cooling the lean meat mass was put into a 20 l capacity comminutor with a 6-knife head (Müller, Saarbrücken-Germany). The total mass of each batch was 3 to 4 kg. The total of sodium chloride or curing salt respectively, one part of ice and the soy additive were added at the beginning of the comminution process. As soon as the temperature in the comminutor was 6°C the minced fat was added and mixed. At the end of comminution the temperature was 12°C. The total time of comminution was between 8 and 10 min. The comminuted meat mass was filled into tin plate cans (size: 73 mm in diameter x 58 mm, net weight of each sample: 200 g). Approximately half of the cans were heated in a boiler at 75°C; core temperature was 70°C. The rest of the cans was sterilized in an autoclave for 65 min. at 120°C (F_C= 4.0). Subsequently all the cans were cooled down to 20°C in water and stored at 2°C.

Soy protein samples

The used soy protein concentrate Promine HV was obtained from the Central Soya Overseas Comp., Rotterdam-Netherlands and the soy isolate S 90 came from Condimenta Comp., Stuttgart-Germany.

The soy proteins were applied in two different forms either dry as powder at the beginning of the comminution process or in water dispersed as a gel.

The hydration of soy protein, the gel dispersion and the emulsion were done in the comminutor in the ratio of 1:4 (soyprotein/water) =soyprotein concentrate or 1:5 (soyprotein/water)=soy protein isolate; water temperature was 15°C, time of mixture was 3 min. The total of each soy protein dispersion was 3 kg. The gained gel was stored for 24 hours at 0°C to 2°C. The emulsion was made in the ratio of 1:4:4 (soyprotein/water/oil) or 1:5:5 respectively. Hereby the oil was added to the gel; emulsion time was altogether 6 min.

The following methods of investigation were performed: approximate analysis, pH-value, a_W-value, fat and jelly rendering, colou firmness, sensory evaluation, electron microscopical observation.

The pH-value measurements were made using an electronic pH-meter (microprocessor-pH-meter 537 with Ingold-puncture ele trode, WTW Comp., Weilheim-Germany).

The a_W-values were measured using an a_W-meter (Novasina AG, Zürich-Switzerland) at 25°C.

The colour measurements (chromatometry) was done using a colour measuring device (Elrephomat DFC 5, Zeiss Comp., Oberk chen-Germany) according to the methods by STIEBING and KLETTNER (1980) and KLETTNER and STIEBING (1980).

Sensory evaluation: A sensory panel consisting of four members evaluated the samples with regard to colour, texture and taste.

Electron microscopy: Samples for the scanning electron microscopy (SEM) were prepared according to the method by KATSAR and STENZEL (1983). The transmission electron microscopy (TEM) method has been described in detail by KATSARAS et al.(198

Results and Discussion

The pH-values of most of the Bologna type sausages either with or without soy protein ranged from 6.2 to 6.4. Although the soy p tein gel (rehydrated soy protein) showed an average pH-value of about 6.4, no rise of the pH-value of the soy protein batches w noted. Instead some slight differences of pH-values were observed by fluctuations among the measured data. Thus we conclu that neither soy protein concentration nor the mode of application have any influence upon the pH-value of the end product. The a values of the samples ranged from 0.977 to 0.979 and were thus almost alike. The located amounts of protein were between 6 and 6.44%. The addition of up to 2% soy protein to the Bologna type sausage did not significantly raise the protein content. Hence tested batches showed almost the same pH-and a_W-values and protein amounts.

Reduction of jelly deposit in fresh meat products (75°C) under the influence of soy protein or phosphate additives was from 1.5 to and hence insignificant (table 1). The Bologna type sausages prepared according to this recipe had meat protein sufficient enou to develop a protein matrix and to immobilize water. Therefore, added soy proteins and phosphate had only an insignificant effect the mild heated meat products. Judging the mode of soy protein addition with regard to jelly deposit showed a tendency to p results with rehydrated soy protein. A fat rendering was not observed at this temperature (75°C). The fully preserved produ (120°C) showed an increase in jelly deposit and fat rendering. Higher temperature resulted in higher shrinkage rate of the pro matrix and in deterioration of the water-fat-binding capacity. The control batches exhibited a jelly rendering of 11.6% and a rendering of only 0.3%. From this we conclude that instability of Bologna type sausage manifests itself mainly in jelly deposit. phosphate batch exhibited a significantly lower jelly deposit (7.7%) than the control batch. Further the fat rendering was slig reduced under phosphate influence. Those batches with soy proteins added were not able to reduce the jelly deposit to suc degree as the phosphate batches were. An overlapping of the obtained results of jelly deposit among the various soy pro batches did not allow to determine further differences within the range of 0.5 to 2.0% soy protein added. Judging the mode of a tion of the soy protein with regard to jelly deposit showed a tendency to poorer results with rehydrated soy protein. This is obvio due to the addition of rehydration water. The reduction of fat rendering was significantly lower than the reduction of jelly deposit. generally low fat rendering made a comparison between the different batches impossible.

The texture of soy protein containing sausages was altogether only sligthly lower than that of the control and phosphate batch The batches with powdery soy protein added appeared to be firmer than that ones with rehydrated soy proteins. The softer co stence of the latter - determined by using an Instron (Instron, Offenbach-Germany) - obviously results from the added rehydra water used as medium for soy protein dispersion. We conclude that the variability of firmness among the Bologna type saus batches treated with different soy protein concentrations was significantly poorer than that of those batches treated with diffe modes of soy proteins addition (either as powder or gel). Higher temperatures (120°C) promoted a higher jelly deposit. remaining sausage mass appeared to be denser and firmer. These changes have a significant effect on the firmness wherefor evaluation of the firmness of the fully preserved products was not taken into consideration.

When determining the colour of mild heated meat products (75°C) the control batch showed - compared with the phosphate and protein batches - a slightly darker colour. The use of soy protein resulted, as expected, in a lighter colour in most of the batches a slight red and a more intensive yellow. Among the soy protein batches there were no significant differences with regard to c centrations. Little difference in colour resulted from different modes of soy protein addition.

The sensory evaluation rendered the following results: The batches treated with powdery soy protein proved to be a little more intensive in colour than those treated with soy protein gel. Significant differences in texture resulted only from the different mode of soy protein addition whereby the batches treated with dry soy protein had a firmer bite than those treated with soy protein gel; the amount of soy proteins added was the same. The sensory evaluation thus confirms the firmness results gained with the Instron. Sensory evalution of smell and taste of control and phosphate batches on the one hand and the soy protein containing sausages on the other hand did not show detectable differences. The phosphate batch (0.2%) exhibited the most intensive meat flavour, better than the control. The use of soy protein up to 1.5% in the batch did not result in a degrading in the sensory evaluation. At higher concentration of soy protein (2%) we detected a different flavour and devalued the samples. It is important to emphasize that these soy protein products were preselected from a number of soy protein products within previous tests and had proved to be of neutral flavour.

With fine comminuted sausages it is necessary to obtain a complete integration of water and fat and consequently a desired deposit-free meat mass. Responsible for the stability of sausage is the structure of the protein matrix. A well developed matrix requires the existence of a sufficient amount of structure building proteins. Generally these are myofibrillar muscle proteins (myosin and actin and actomyosin respectively) developing a stable structure in the sausage mass. The addition of soy proteins would provide the amount of structure building proteins for the matrix development and would thus increase the stabilizing effect when subjected to heat treatment.

Rehydrated soy proteins soak and simultaneously change their structural pattern (Fig. 1). When subjected to mechanical stress - as is the case with each homogenization (comminution) - the rehydrated soy protein particles decompose in aggregation-ready segments to form soluted proteins. In the course of these structural changes the rehydrated soy proteins aggregate with each other creating protein accumulations. The restructured soy protein is then to be mixed with the meat protein network by further comminution.

In this connection the question arises whether standard soy proteins contribute to the development of the meat protein network and would thus function as fat stabilizing factor; or whether standard soy proteins establish only separate areas within the meat system. Meat proteins develop a protein matrix during production of Bologna type sausage. This matrix mainly consists of soaked myofibrillar fragments, filamentous elements and soluted proteins (Fig. 2). In contrast to this soaked soy proteins develop a closely interwoven, dense, three-dimensional matrix, with evenly distributed, compact, electrondense, round shaped particles (Fig. 3). The soy protein matrix determines many rheological parameters, and as an autonomous structure immobilizes not only water but also holds fat globules (Fig. 4). We conclude that soy protein gel has emulsion properties and differs significantly from meat protein gel. These soy protein structures which appear in the sausage mass are in limited number but seem to be partially connected to the meat protein matrix via certain contact areas (Fig. 5); contact to fat particles is rare. Bologna type sausage structures containing soy protein gel in micro areas exhibited that the addition of up to 2% of soy protein to protein-rich meat had no visible effect on fat stability, this observation was confirmed by light microscopic investigations. There is still one open question namely whether those in the watery phase soluted soy proteins after being distributed throughout the sausage mass and mixed with the meat proteins are capable of a meat protein/soy protein reaction and thus become integrated into the meat system to function as a supporting factor in the structural development of a meat protein matrix.

From the technological and morphological results it can be concluded that soy proteins added in relatively small amounts to sausages of high meat content not always develop all their positive functional properties (water-fat binding) to full scope and maximum effect. According to MEESTER (1969) the use of soy protein and of Na-caseinate, as the case may be, has no noticeable advantage in Bologna type sausages with a high content of meat proteins.

Relating to the physiology of nutrition the future demand is increasing for Bologna type sausages the components of which deviate from the traditional meat products. In this connection the almost fat free soy proteins are not only welcomed with regard to producing fat reduced Bologna sausages but also - due to their gel forming properties - as a supporting element in the structural development of the meat protein matrix. Sodium reduced Bologna type sausages are welcomed nutritionally as well, however their production requires different technology (WIRTH, 1988). Reduction of sodium chloride with regard to Bologna type sausage has a negative effect especially on the binding capacity of meat protein and must therefore be compensated. The reduced technological efficiency of meat proteins can be compensated by the use of soy proteins.

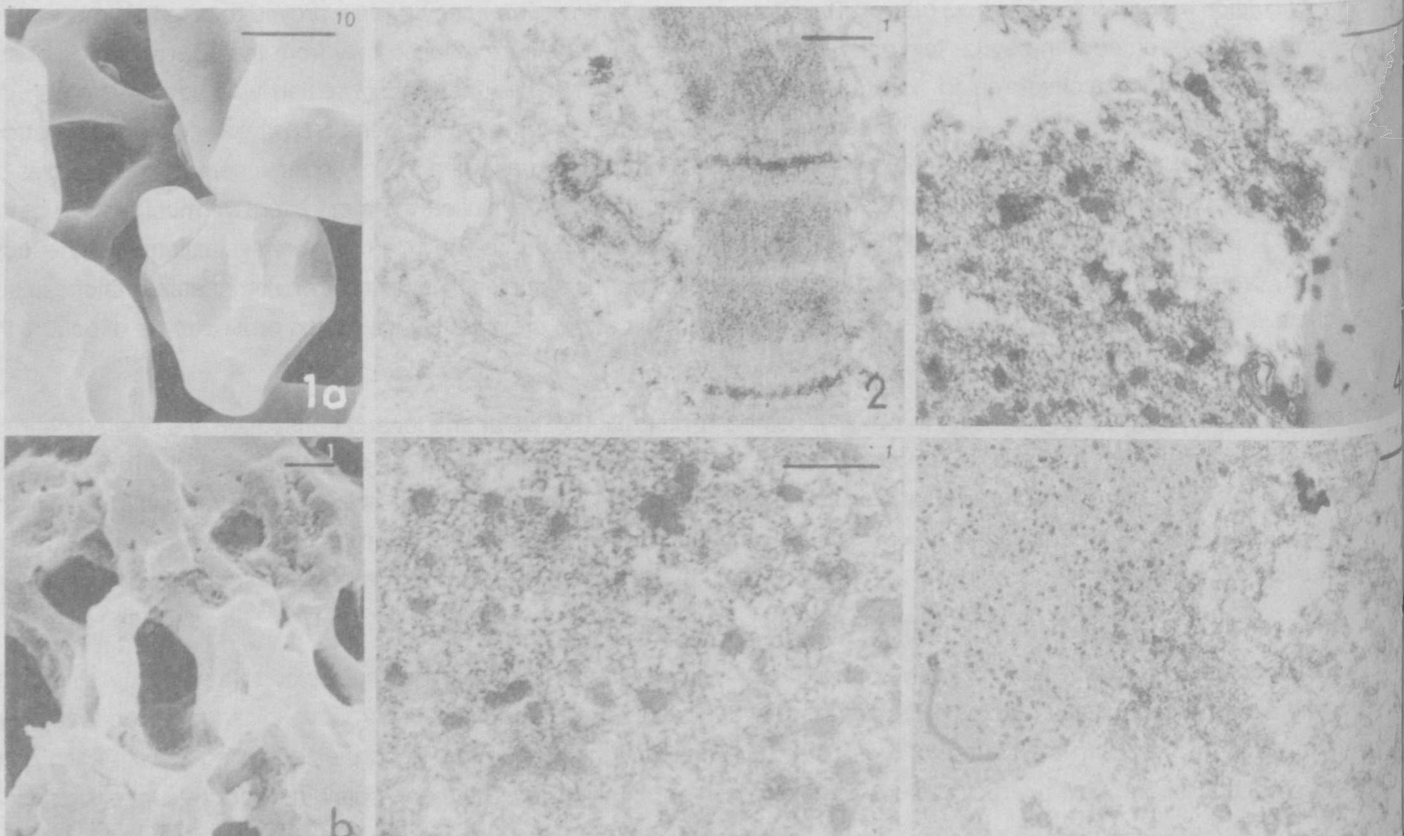

Fig.1: (a) Powdery soy protein (SEM, 860 x), (b) rehydrated soy protein (SEM, 5 000 x); **Fig.2:** Soaked myofibrillar fragments filamentous elements and soluted proteins in sausage matrix (TEM, 12 500 x) **Fig.3:** Soy protein matrix with electron denser particles (TEM, 20 000 x); **Fig.4:** Soy protein matrix and fat particle (TEM, 20 000 x); **Fig.5:** Soy protein structure connected to the meat protein matrix (TEM, 5 000 x).

Table. 1: Jelly and fat rendering and firmess of mild heated Bologna type sausages (75°C) and fully preserved products (120°C) respectively

Sample	Jelly/fat 75°C	Jelly/fat 120°C	firmness 75°C
Control	1,5 / 0	11,6 / 0,3	22,86
Phosphat control	1,3 / 0	7,7 / 0,2	23,54
0,5 % S 90	1,3 / 0	8,5 / 0,2	22,15
0,5 % Promine HV	1,5 / 0	10,9 / 0,4	22,58
1,0 % S 90	1,4 / 0	9,1 / 0,2	23,22
1,0 % Promine HV	1,0 / 0	10,4 / 0,1	22,94
1,5 % S 90	1,0 / 0	9,0 / 0,2	22,19
1,5 % Promine HV	1,3 / 0	9,4 / 0,2	22,66
2,0 % S 90	1,3 / 0	8,7 / 0,4	22,22
2,0 % Promine HV	0,9 / 0	8,7 / 1,1	21,23
0,5 % S 90	0,8 / 0	10,0 / 0,3	19,15
0,5 % Promine HV	0,8 / 0	9,4 / 0,2	19,89
1,0 % S 90	0,9 / 0	9,5 / 0,2	18,50
1,0 % Promine HV	0,9 / 0	10,7 / 0,2	18,04
1,5 % S 90	1,0 / 0	9,0 / 0,4	18,38
1,5 % Promine HV	0,9 / 0	9,9 / 0,2	17,94
2,0 % S 90	1,0 / 0	10,5 / 0,2	17,55
2,0 % Promine HV	1,1 / 0	10,6 / 0,1	16,91

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