Technological properties of frozen meat grinded on a frozen meat grinder.

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The effects of frozen storage on the functional properties of meat, have been the theme for several investigations. Miller *et al.* (1980) reported changes in several properties resulting from storage at -17.8°C (1-37 wk). Matsumoto (1980) reported on freeze denaturation of muscle proteins. Nusbaum *et al.* (1983) studied effects of freezing rate while Gumpen and Fretheim (1981) focused upon the technological properties of frozen and refrozen meat.

In the production of sausages, special grinders have been constructed for the grinding of frozen meat. In an earlier investigation (Gumpen, 1978) it was concluded that the use of frozen meat grinders resulted in "a severe reduction in the meat's ability to give high quality sausage products". Meat grinded at -20°C to -30°C gave products with a loose texture and a reduced fat holding capacity probably resulting from denaturation of the muscle proteins and destruction of fat-cell membranes during the grinding process, respectively. These effects increased with increasing fat content of the meat. The conclusions from this investigation have been discussed further by Tändler (1982).

The aim of the present investigation was to study the effect of the grinding temperature on the technological properties of deep frozen meat. Meat samples were tempered to -20°C, -7°C, -2°C and -0.5°C, respectively, before grinding. After the grinding process, the properties of the meat samples were analysed by instrumental methods and sensory evaluation.

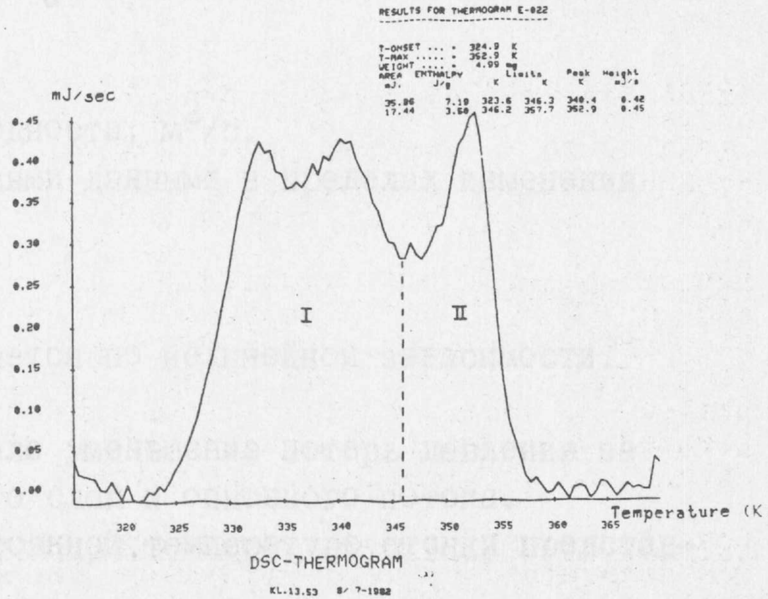
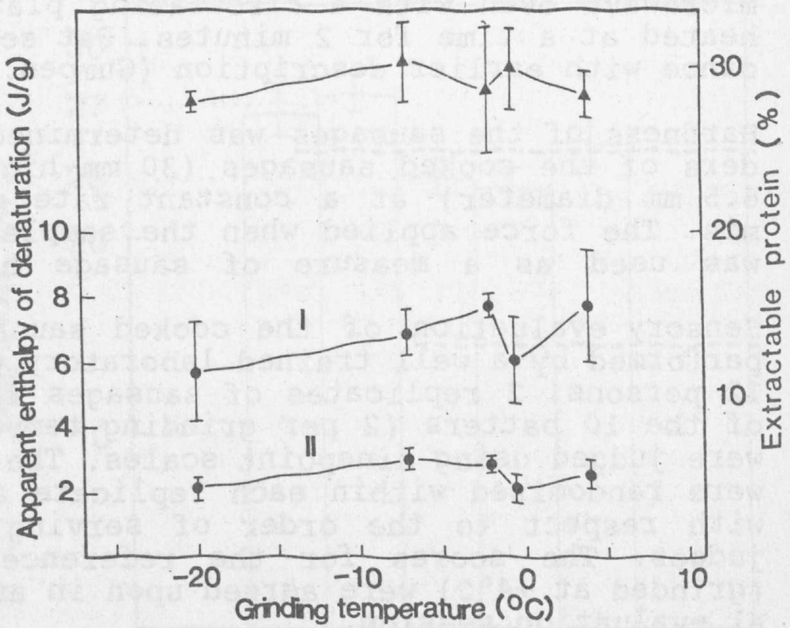


Fig. 1. A typical meat thermogram after baseline subtraction and computer manipulation. The areas I and II represent roughly the apparent enthalpy of denaturation of myosin and actin, respectively (Stabursvik & Martens, 1980).

Materials and Methods

Meat source and treatments. Five 20 kg samples of the same batch of standardized, fresh beef (containing 22% fat and 17.2% protein) were delivered from a meat supplier. Four samples were frozen at -30°C, stored frozen for 4 days, tempered to -20°C, -7°C, -2°C and -0.5°C for 3 days and then grinded on a frozen meat grinder in common use in the meat processing industry. The last sample was grinded fresh at +4°C.



Differential scanning calorimetry was performed on 15 mg samples of fat-free muscle tissue (Gumpen, 1978) in a Perkin Elmer DSC-2 connected to a computer (Harbitz, 1983). A typical meat thermogram after base-line subtraction is shown in Fig. 1.

Total extractable protein was determined using a method described by Gumpen and Fretheim (1983). 10 g samples were thawed at +4°C, ground through a 2 mm grinder plate and mixed with 100 ml of the extraction buffer.

Extractable fat was determined after thawing and grinding of 70 g samples. 350 ml n-hexane was added to each sample before stirring at 20°C for 5 hours. The meat particles were allowed to sediment, the n-hexane was then evaporated away from 10 ml samples of the supernatant and the remaining fat weighed.

Loss in weight of model hamburgers on frying was determined by weighing before and after controlled frying. The model hamburgers were produced from the meat samples after addition of NaCl (1.5%) and grinding through a 2 mm grinder plate.

Cooked and smoked sausages were produced in a 10 l Müller bowl chopper following a standardized procedure. NaCl (1.8%), potato starch

Results and Discussion

The degree of denaturation of the muscle proteins resulting from the grinding of frozen meat was determined by two different techniques. Differential scanning calorimetry thermograms were devided into two areas as shown in Fig. 1. The apparent enthalpies as shown in Fig. 2, were independent of the grinding temperature on a 99% level of significance. Also the total extractable protein seemed to be unaltered for all the grinding temperatures tested. As a conclusion there is no evidence from the data presented in Fig. 2 that grinding of frozen meat results in a dramatic denaturation of the meat proteins.

Extractable fat. In Fig. 3, the amount of extractable fat is presented. From the figure and the statistical analysis it is evident that in meat grinded at -20°C and -7°C the amount of extractable fat is much higher than in the 3 other samples. This phenomenon is probably resulting from the rupture of fat cells during grinding (Gumpen, 1978, Tinberger & Olsman, 1979).

Weight losses of model hamburgers on frying are presented in Fig. 4. The weight losses of hamburgers produced from meat grinded at the lower temperatures (-20°C and -7°C) are significantly higher than for hamburgers produced from the fresh reference or from meat grinded at the higher temperatures (-2°C and -0.5°C). The reason for this effect is probably that more of the fat is free to escape in the first two cases. The economic implications of this finding are obvious.

Fat and water holding capacities of the cooked sausages. In Fig. 5 the influence of the grinding temperature on the fat holding capacity (presented as fat separation) of the sausages is shown. The results are analogous to those for extractable fat in the raw, grinded meat (Fig. 3). Clearly, grinding at -2°C or -0.5°C results in a fat holding capacity comparable to the capacity of products made from meat grinded fresh. The effect on moisture loss (Fig. 5) seems to be less pronounced.

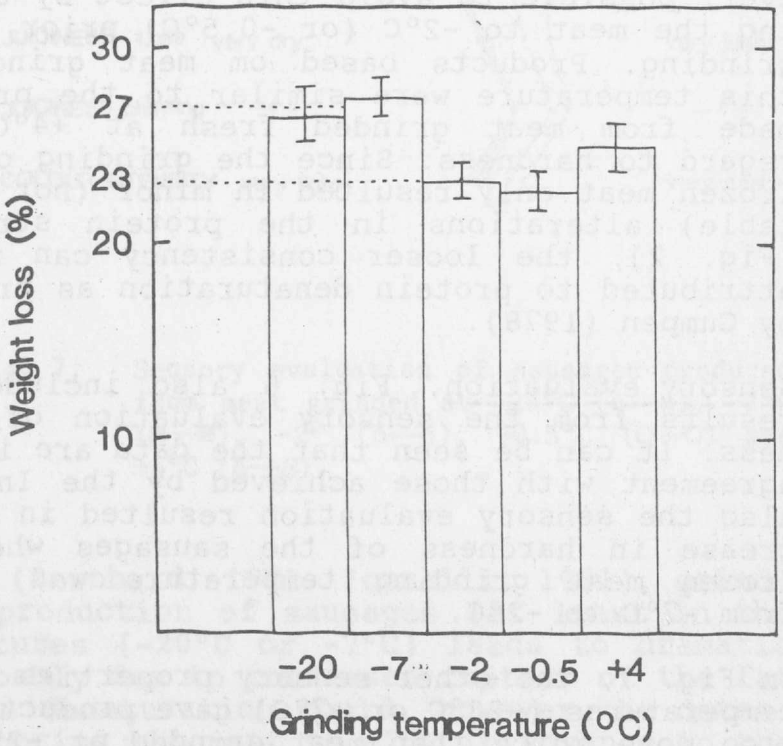


Fig. 4. Total weight loss on frying of model hamburgers (20 replicates).

(3.7%), skimmed dry milk (1.8%) and spices were added. The final raw batter weighed approx. *4.0 kg and contained* 8.7% protein and 22.6% fat. It was treated by an emulsion mill before *stuffing into* Naturin collagen casings (36 mm). The sausages were cooked to a core temperature of 74°C and smoked. Two batters were produced from each of the grinded meat samples.

Fat and water holding capacity of the sausages were determined using a microwave oven technique. Samples of the cooked sausages (30 mm high, 17 mm diameter) were treated in a Sharp microwave oven with a circulating plate. The output power was 600 W and 10 samples were heated at a time for 2 minutes. Fat separation and moisture loss were determined in accordance with earlier description (Gumpen, 1978).

Hardness of the sausages was determined with an Instron Universal Testing Machine. Cylinders of the cooked sausages (30 mm high) were compressed/penetrated by a cone (10 mm high, 6.5 mm diameter) at a constant rate of 5 cm/min. The force applied when the sample breaks, was used as a measure of sausage hardness.

Sensory evaluation of the cooked sausages was performed by a well trained laboratory panel of 12 persons. 2 replicates of sausages from each of the 10 batters (2 per grinding temperature) were judged using ninepoint scales. The samples were randomized within each replicate and also with respect to the order of serving to the judges. The scores for the reference sample (grinded at +4°C) were agreed upon in an initial evaluation session.

Statistical analyses. Analysis of variance of the data-matrix from the chemical and instrumental analyses was performed by a studentized range test of means (tests of significance on a 99% level), while a studentized range test due to Turkey was used for the analysis of the data from the sensory evaluation. In the figures mean values are given ± 2 x standard error of the mean. The number of replicates are given in the legends.

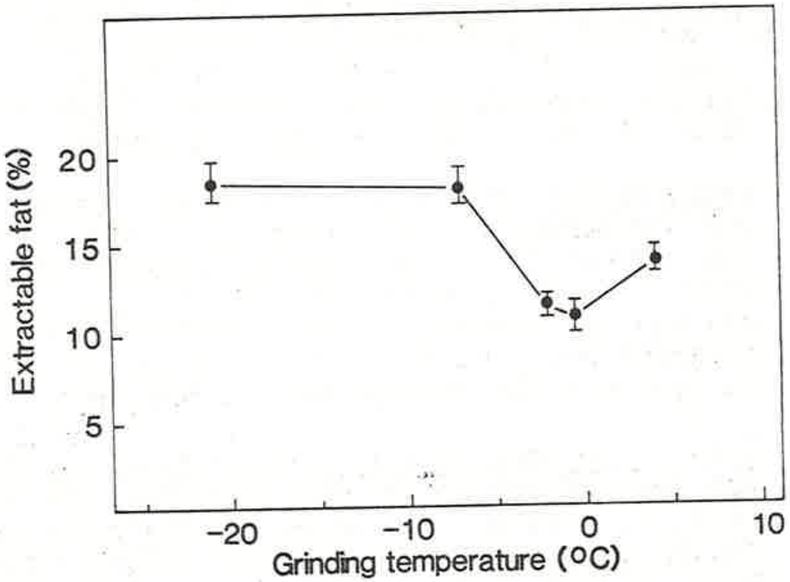


Fig. 3. The amount of extractable fat given in % of the total sample weight as a function of the grinding temperature (6 replicates).

Texture. The hardness of the cooked sausages was determined instrumentally and the data are presented in Fig. 6. Consistent with the findings of Gumpen (1978), the sausages produced from meat grinded on the frozen meat grinder at -20°C possessed a loose consistency. It is, however, possible to avoid this effect by tempering the meat to -2°C (or -0.5°C) prior to the grinding. Products based om meat grinded at this temperature were similar to the products made from meat grinded fresh at +4°C with regard to hardness. Since the grinding of deep frozen meat only resulted in minor (not detectable) alterations in the protein structure (Fig. 2), the looser consistency can not be attributed to protein denaturation as proposed by Gumpen (1978).

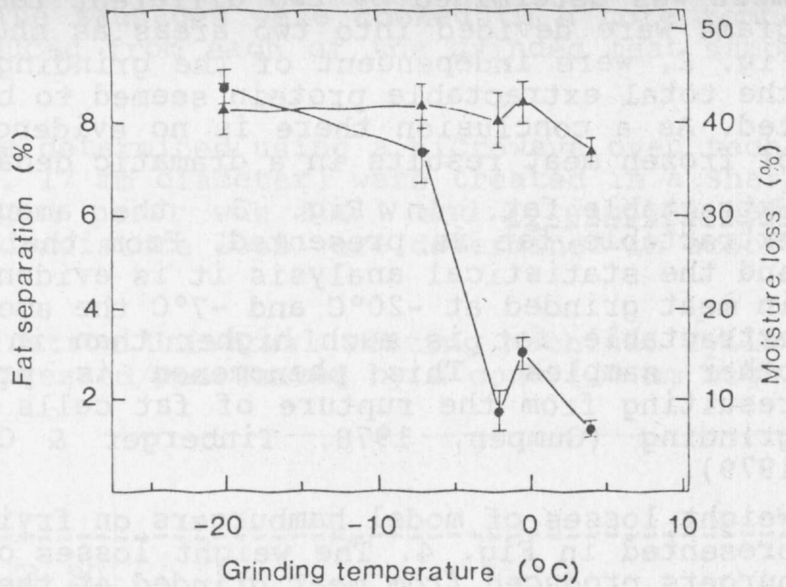


Fig. 5. Fat separation (●—●) and moisture loss (▲—▲) of the sausages determined by a microwave oven technique as a function of the grinding temperature of the meat (6 replicates).

Sensory evaluation. Fig. 6 also includes the results from the sensory evaluation of hardness. It can be seen that the data are in good agreement with those achieved by the Instron. Also the sensory evaluation resulted in an increase in hardness of the sausages when the frozen meat grinding temperature was raised from -7°C to -2°C.

In Fig. 7, the other sensory properties of the sausages are presented. Meat grinded at low temperatures (-20°C or -7°C) gave products judged more coarse, more adhesive, more oily and also more juicy than meat grinded at -2°C, -0.5°C or +4°C (fresh). The colour was judged significantly darker in sausages made from meat of the first group. The differences between the scores of the two groups are significant on a 99% level for hardness, adhesiveness, oiliness and juiciness (1. bite), and on a 95% level of significance for coarseness, juiciness (chewing) and colour intensity. No differences between the samples were found for meat-flavour and off-flavour.

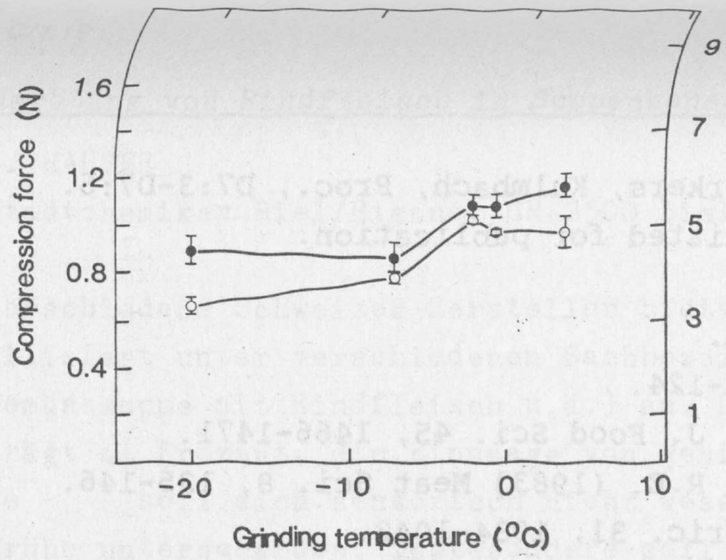


Fig. 6. Hardness of the sausages determined both instrumentally (●—●) (12 replicates), and sensory (o—o) (Sensory scale : 1=not hard, 9=very hard).

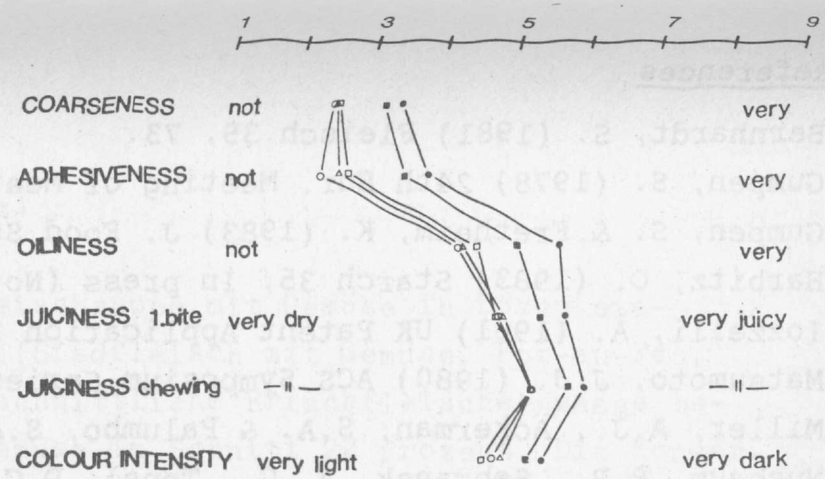


Fig. 7. Sensory evaluation of sausages produced from meat grinded at -20°C (●—●), -7°C (■—■), -2° (o—o), -0.5°C (□—□) and +4°C (Δ—Δ).

Conclusion

Although machinery for cutting frozen meat exists (Bernhard, 1981, Iozzelli, 1981), grinding of deep frozen meat is still common in the production of sausages (at least in the Scandinavian countries). Grinding at low temperatures (-20°C or -7°C) leads to dramatic changes of the properties of the fat present, probably due to increased rupture of the fat cells. Only minor effects on the degree of protein denaturation could, however, be detected. The problems can be completely avoided by tempering the meat to -2°C in advance to the grinding process. The frozen meat can then be grinded without alterations of the technological properties, without formation of drip and no sticking of fat in the grinder.

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