Das Mahlen von tiefgefrorenem Fleisch. Der Effekt auf die Binde-Eigenschaften

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Tiefgefrorenes Fleisch wird in vielen Ländern oft zur Wurstproduktion verwandt. Spezialkonstruierte Fleischwolfmaschinen, die das tiefgefrorene Fleisch mahlen, werden jetzt häufig gebraucht. Diese machen die rationelle Behandlung des gefrorenen Fleisches möglich.

Wir haben die Binde-Eigenschaften des Fleisches von zwei dieser Industrie-Wölfe untersucht. Wir haben festgestellt, dass es schwierig ist, aus solchem gemahlenen Gefrierfleisch Würste von hoher Qualität herzustellen. Die Probe-Würste hatten eine starke Tendenz, das Fett auszuscheiden, wahrscheinlich wegen zerstörter Fettzelle-Membranen. Ausserdem hatten die Würste eine lose, unzureichende Textur, wahrscheinlich wegen der Denaturierung von Muskelprotein während der Mahlung.
Diese Folgerung bezieht sich auf Instrument-Messungen von Textur, einfacher Flüssigkeitsextraktion, und auf Untersuchungen von Protein-Denaturierung mit kalorimetrischer Technik, "differential scanning calorimetry" (DSC).

Grinding of deep-frozen meat. Effects on binding properties.

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Frozen meat is widely used for production of sausages in many countries. In recent years specially designed grinders have been introduced. These allow grinding of meat in the deep-frozen state and thereby a more efficient production.

In a study of the binding properties of ground frozen meat from two grinders used in the Norwegian meat industry, we found a severe reduction in the meat's ability to give high quality sausage products.

A significant increase in fat separation was observed, probably caused by destruction of fat-cell membranes. Also, an unsatisfactory, loose texture of the cooked products was evident, probably caused by denaturation of muscle proteins during the grinding process. These conclusions are based on instrumental texture measurements, simple solvent extraction techniques and on examination of protein denaturation by differential scanning calorimetry.

Le broyage de la viande surgelée. Les effets sur les propriétés de consistance.

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Dans plusieures pays, la viande gelée est beaucoup utilisée dans la production des saucisses. Durant les dernières années, des moulins à viande spécialement concus ont été introduits. Ceux-ci permettent le broyage de la viande à l´état surgelé, ce qui améliore l´efficacité de la production.

Lors d´une étude protant sur les propriétés de consistance de la viande gelée et broyée à l´aide de deux moulins à viande utilisée dans l´industrie bouchère norvégienne, nous constatons une sérieuse réduction de la capacité de la viande à produire des saucisses de haute qualité.

On constate une augmentation significative de la séparation des graisses, probablement causée par la destruction des membranes des cellules graisseuses. De plus, les produits, cuits présentent une consistance lâche et non satisfaisante, probablement causée par la dénaturation des protéines du muscle durant le processus de broyage. Ces conclusions sont basées sur des mesures instrumentales de la texture, sur des techniques d´extraction par solvant et sur l´examen de la dénaturation des protéines par calorimétrie différentielle enregistrée en scanning (DSC).

По вопросу промалывания мяса глубокой заморозки. Влияние на связывающие свойства.

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Мороженое мясо широко используется в изготовлении колбасных изделий во многих странах. В последнее время в промышленности внедряются мясорубки специальных конструкций. С их помощью стало возможным промалывать мясо,находящееся в состоянии глубокой заморозки, что ведет к более эффективному производству.

Исследуя связывающие свойства фарша глубокой заморозки,который производится двумя типами мясорубок в промышленности Норвегии,мы обнаружили резкое снижение качества колбасных изделий.

Зафиксировано значительное увеличение отделения жира,что,вероятно,было вызвано разрушением оболочки жировой клетки. К тому же совершенно очевидна слабая натяжка пленки вареных колбасных изделий. Возможная причина - денатурация мышечного протеина в процессе промалывания.Эти выводы сделаны на базисе инструментального измерения пленки изделий,технике простого экстрационного растворителя и на исследовании денатурации протеина дифференциальной сканирующей калориметрией.

Grinding of deep-frozen meat. Effect on binding properties.

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Introduction

Deep-freezing has become a common way of preserving meat. In Norway, meat for sausage production is normally frozen in portions of 20 kg after adjusting the fat and moisture contents to specific levels. Cow 1, Cow 2 and Cow 3 are three quality grades of commercial meat cuts containing about 3, 14 and 27% fat respectively. Of these, Cow 2 and Cow 3 are the main ingredients of many emulsion type sausage products.

By common practice the sausage maker has allowed a partial thawing of the meat prior to further processing in the bowl chopper. In recent years, however, meat processors have begun to grind the frozen meat in specially designed grinders without preceding tempering. This works quite well from an efficiency point of view, but possibilities are introduced for deleterious effects on the meat due to high pressures and shear forces. This paper summarizes the results of a study of how the technological properties of the three quality grades of cow meat are affected by grinding in the deep frozen state. Both acute effects caused by the grinding process per se and long term effects due to altered storage stabilities were investigated.

Materials and Methods

Grinders

Two different grinders (here called A and B) in current use in Norwegian meat processing plants were studied. The grinders were equipped with 50-75 kW drive motors. Six and eight mm hole plates were used.

Meat source and treatments

Three 20 kg cartons of the same batch of standardized, frozen meat of each of Cow 1, Cow 2 and Cow 3 were delivered by a main meat supplier. One sample (20 kg) of each grade of meat was ground in the deep-frozen state (-20 to -30°C) through grinder "A", one sample through grinder "B" and the last sample of all grades, the reference or control sample ("R"), was cut without thawing into pieces of approximately 0,5 to 5 cm length by means of a meatsaw and a bowl chopper. When ground or chopped each meat sample was thoroughly mixed, rendering it possible to subdivide all samples into representative portions of 1 kg. The 1 kg portions were left in polyethene bags at -10°C.

Investigations by the methods described below were performed one to two days after grinding ("acute effects") or after 50 days of storage (long-term effects due to altered storage stability). The meat samples were thawed at +4°C over night prior to being studied by the various methods.

Protein extraction

After complete thawing the meat samples were ground through the 3 mm plate of a laboratory grinder. In each case the ground material was thoroughly mixed, and 20 g samples were stirred with 60 ml 1 M sodium chloride (5,8%) at +4°C for four hours. Aliquots were centrifuged at 27 000 x g for 15 min at +4°C, and the percentage of extractable proteins was calculated from the Kjeldahl-N x 6,25 of the supernatants.

Studies of protein denaturation by differential scanning calcrimetry

Samples (15 mg) free of visible fat and connective tissue were weighed into the standard aluminium pan and studied in the Perkin-Elmer DSC-2 Differential Scanning Calorimeter. The scanning rate was 10°C/min. and thermograms were recorded against 15 µl of distilled water in the reference pan.

Production of cooked emulsion type sausages

Batters containing 10% protein, 20% fat and 63% water were produced in a 10 l Müller bowl chopper following a standardized procedure. One or two kg of meat were used, and the fat and water content of the batters were kept constant by varying the amount of pork backfat and water added. Two per cent salt was used, and 4% potato starch and 2% skimmed, dry milk were added as binders. The emulsions were stuffed into 32 mm casings and cooked in a water bath for 5 min at 85°C + 15 min at 80°C. After cooking, the sausages were cooled by cold tap water.

Evaluation of fat binding in sausages by a microwave oven heating method

Cylindrical samples (18 mm diameter, about 7 g) of the cooked and cooled sausages were heated to 100°C in petri-dishes in the center of a Husquarna Type 20030 microwave oven for 30 sec. The sample was discarded, and the amount of fat separated during heating was calculated from the weight increase of the petri-dish after drying to constant weight at 70°C in a vacuum-oven.

Instrumental texture measurements of cooked sausages

Sample cylinders of the cooked sausages, 10 mm high and 18 mm in diameter, were compressed axially in an Instron Universal Testing Machine at a constant rate of 5 cm/min. The sample temperature was 22±1°C. The force exerted on the load cell at 33% compression of the sample cylinder (F1/3), was taken as a measure of sausage texture. At this stage of compression there was no break of the samples.

Results and discussion.

Protein extraction

The per cent extractable protein from the different meat samples are shown in Table 1. The high values of about 40% reflect an efficient extraction procedure. Analyses of variance reveal no difference between the three types of treatment (A,B and R). However, the "acute effect" results for meat grade Cow 3 differ from the trend in the results for the rest. This is quite surprising and hard to understand. Since redoing the entire experiment involving Cow 3 was judged too time consuming and expensive, an explanation in terms of accidental circumstances of the experimental work lies close at hand. Anyway, if all Cow 3 values are excluded from the statistical analyses, significant reductions of the per cent extractable protein due to grinding in the frozen state are evident. The reductions are small, however, and reduced protein solubility per se cannot explain any reduction of the binding properties of the meat.

Table 1. Extractability of meat proteins as affected by grinding in the frozen state.

Meat grade	Sample	Extractability 1 day after grinding *	Extractability 50 days after grinding *
Cow 1	R	39,7±0,8	37,6±0,3
	A	37,6±1,3	37,3±0,0
	B	36,9±0,5	36,4±0,0
Cow 2	R	38,5±0,0	39,8±0,7
	A	37,4±0,0	37,4±0,0
	B	37,1±0,3	36,7±0,3
Cow 3	R	39,1±0,4	39,6±0,9
	A	44,2±0,5	39,1±0,9
	B	40,0±0,0	36,9±0,4

Cow 1, Cow 2, Cow 3 - commercial cuts of meat containing about 3, 14 and 27% fat, respectively.
R - untreated reference samples
A,B - meat samples ground in the frozen state in grinder A or B.
*- g protein extracted/100 g protein in meat sample mean ± S.E. of four samples.

Protein denaturation studied by differential scanning calorimetry

DSC-studies of meat samples give rather complicated thermograms with three overlapping main peaks. The peak areas can be taken as measures of the heat absorbed during the denaturation of myosin (Peak I), collagen/water soluble proteins (Peak II) and actin (Peak III), respectively. Two typical thermograms are shown in Fig. 1, demonstrating three major findings of this study:

a. The total peak area (total heat absorbed) is significantly reduced in the thermogram of the meat samples that are ground in the frozen state (A and B) as compared with the control sample (R).
b. The area of the actin peak relative to the total peak area is reduced in the samples of meat ground in the frozen state.
c. T_{max} of the actin peak is reduced from 82 °C to 79,5°C due to grinding the meat in the frozen condition.

These findings apply to both grade 1 and 2 of the cow meat. Grade 3 was not included in these measurements.

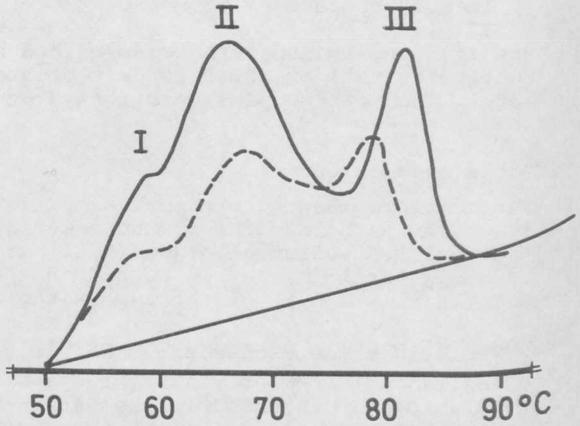

Fig. 1. Typical differential scanning calorimetry thermograms of meat samples (15 mg) free of visible fat and connective tissue. Scanning rate 10°C/min.

——— reference meat sample
------- freeze-ground sample

In our interpretation this DSC-study gives clear indications that a general protein denaturation is caused by the high pressure and shear forces involved in the grinding process (finding a). The tertiary and intermolecular structures of actin seems to be especially destabilized (findings b and c).

The results of all measurements relative to values of control samples of Cow 1, are given in Table 2. Total areas are measured by the "cutting and weighing method" while the height of the actin peak was taken as the best measure of its area since overlapping makes a direct estimation of the peak area difficult. It can be shown that the height of the actin peak is not influenced to a significant degree by overlapping. Furthermore, the DSC peak geometry is approximately that of an isosceles triangle with constant base length, giving direct proportionality between peak height and peak area.

Table 2. DSC thermograms of meat samples as affected by grinding in the frozen state. Relative values of total peak area and of actin peak area/total peak area.

Meat grade	Cow 1			Cow 2		
Sample	R**	A	B	R	A	B
Total area *	100+5 (9)	74+5 (8)	67+4 (7)	88+1 (4)	67+11 (4)	64+11 (5)
Actin peak/total peak*	100+6 (9)	75+2 (8)	85+2 (7)	100+2 (5	81+4 (4)	75+5 (5)

* mean ± S.E. (number of samples in brackets)
** mean values of reference samples of Cow 1:=100
See also Fig. 1 and legends Table 1.

Sausages fat binding

A considerable oiliness of the sausages made from frozen ground meat as compared to the reference samples was noticed by simple tasting. The reduced fat binding in these sausages could also be detected by observing the cut of half a sausage during compression.
These differences in fat binding could be further measured and verified by heat treatment of sausage samples in the microwave oven as described above.

The results of measurements of fat separation during microwave heating are shown in Fig. 2.

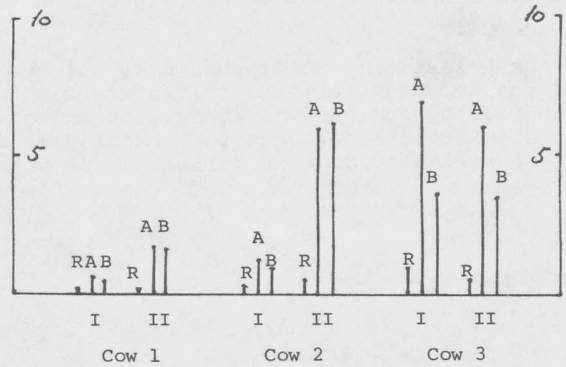

Fig. 2. Fat separation (g fat/100 g sample weight) during microwave heating of cylindrical samples (18 mm Ø, 10 mm length) of cooked sausages. Heating time 30 s.
I - sausages produced ≤ 2 days after grinding
II - sausages produced after 50 days storage of the ground meat at -10°C. See also legends Table 1.

The sausages made from control meat separated modest amounts of fat, corresponding to good fat binding properties of the batters. With all grades of meat, grinding in the frozen condition gave sausages with poor fat binding ability. Fat separation was the most severe from sausages made from fat-rich meat cuts. The results indicate that fat separation results mainly from the damage of fat cells rather than from a reduced capacity of the muscle proteins to bind fat.
In addition to this acute effect of the damaged fat cell membranes, the results show that storage of the frozen-ground meat causes a significant further relative reduction of the fat binding properties of the sausages produced.

Sausage texture

Sausages made from frozen-ground meat were all of a loose, unsatisfactory texture, while reference samples made from control meat consistently were of high textural qualities. Sausages produced from 43 batters of meat ground when frozen and from 19 batters of control meat gave no exception to this generalization.

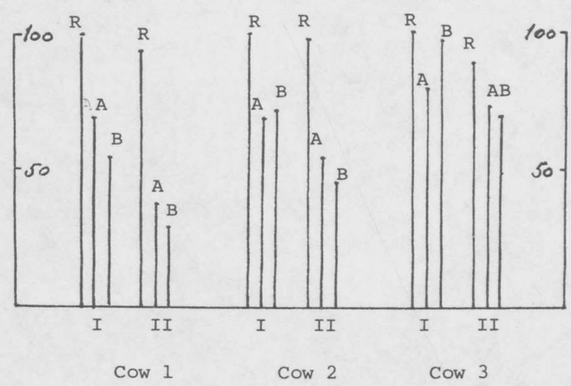

Fig. 3. Texture of cooked sausages. Forces at 33% axial compression of cylindrical samples (18 mm Ø, 10 mm length). Compression rate 5 cm/min. Temperature 22±1°C.
I - sausages produced ≤ 2 days after grinding.
II - sausages produced after 50 days storage of the ground meat at -10°C. Within each grade of meat the results are expressed as per cent of the ≤ 2 days reference sample (RI).
See also legends Table 1.

Relative F1/3-values, i.e.forces at 33% compression of the samples, are shown in the histograms of Figure 3. The values obtained for reference samples within two days after grinding, are set to 100%.

Texture is a complex property making an extensive description of texture by a single parameter impossible. Conversely, any one textural notation, i.g. F1/3, has a complex relationship to the physico-chemical properties of the object under investigation. Thus, F1/3 of the sausages is not a clearcut measure of the strength of the gel formed by the salt soluble proteins of the muscles; it is also influenced by the type of fat and the collagen content of the sausages. This is probably the explanation why the effects of freeze-grinding on the textural properties of sausages from Cow 3 is small compared to the effects observed for Cow 2 and Cow 1. The high levels of collagen and fat in the Cow 3 samples make significant contributions to the F1/3-values of the corresponding sausages, while the values for the Cow 1-sausages are mainly determined by strength of the protein gel.

The results of measurements on sausages made from meat stored for 50 days at -10°C, indicate a further impairment of the gelforming properties of the freeze-ground meat samples, parallelling the decrease in fat binding mentioned earlier.

Concluding Remarks

The results presented in this paper points to grinding of meat in the deep-frozen state as a possible source of quality problems associated with some modern sausage production lines.

Whether the observed property impairment of the freeze-ground meat can be overcome or circumvented by special measures during the production has not been considered.

If freeze-grinding is used by a meat processor, and quality defects of the types described are suspected, a reliable precaution would be to temper or partially thaw the meat before grinding.

As a last comment it should be pointed to the fact that although our intention was to study the immediate effects of freeze-grinding per se, there was a time lag of 1-2 days between grinding and sausage production in our "acute effects" measurements. This length of time significantly exceeds the normal time lag of industrial sausage production. The possible significance of this difference is not known.