Neue Erkenntnisse der Fett- und Wasserbindung in Wurstbräten

Ernst J.C. Paardekooper und Bryan J. Tinbergen
NIEDERLÄNDISCHES ZENTRUM FÜR FLEISCHTECHNOLOGIE, Abteilung des Zentralinstituts für Ernährungsforschung - TNO, Zeist, Niederlande

Es ist nicht vollkommen bekannt, wie die Hitzestabilität eines Wurstbrätes zustande kommt. Es gibt zwar viele Literaturstellen mit der Hypothese, dass ein Wurstbrät aufgefasst werden muss als eine Emulsion von Fett in Wasser mit (Fleisch)eiweiss als Emulgator, aber die mikroskopische Untersuchung vor und nach der Erhitzung ergibt ein heterogenes Bild, wobei das Fett hauptsächlich in unverletzten Zellen vorkommt.
Weitere Untersuchungen der Fett- und Wasserbindung eines Brätes während der Erhitzung zeigen, dass innerhalb von weiten Grenzen der Kuttertemperatur die Menge des extrahierbaren Fettes signifikant positiv korreliert ($P < 0.01$) mit dem Fettabsatz. Das bedeutet, dass die Unverletztheit der Fettzellen die Hitzestabilität bestimmt und nicht die Menge des ausgetretenen Fettes, die emulgiert werden kann. Experimente mit fettlöslichen Farbstoffen zeigen eine bedeutende Fettmigration während der Erhitzung von nicht stabilen Bräten.
Die Wasserbindung einer Mischung von feingekuttertem Fleisch, Salz und Wasser (Farce) wurde bestimmt als Funktion der Kutterzeit und der Farcetemperatur. Die Bestimmung erfolgte durch Wägung des Geleeabsatzes nach Erhitzung in Dosen. Die Wasserbindung erreicht einen Höchstwert nach 4 min (0° C), bleibt konstant bis 15 min (18° C) und sinkt dann allmählich, sichtbar in zunehmenden Geleeabsatz.
Von jeder Farce wovon die Wasserbindung bestimmt wurde, wurde ein Wurstbrät hergestellt durch Zusatz von Rückenspeck. Die Wasserbindung des vollständigen Brätes korreliert immer mit der Wasserbindung der Frace bei allen angewandten Farcekutterzeiten. Die Fettbindung des erhitzten Brätes korreliert signifikant mit der Unverletztheitsgrad der Fettzellen.
Die Ergebnisse werden diskutiert im Ramen der modernen Wursttechnologie.

New information on fat and water binding in comminuted meat products

ERNST J.C. PAARDEKOOPER and BRYAN J. TINBERGEN
Netherlands Centre for Meat Technology, dept. of Central Institute for Nutrition and Food Research TNO

The mechanism involved in the heat stabilization of sausage batters is not completely understood. Hypotheses to consider comminuted meat batters as fat-water emulsions with (meat)proteins as emulsifiers are widely spread in literature. However, microscopical evaluation of sausage and luncheon meat type mixtures before and after heating reveal a more heterogeneous structure in which the fat predominantly appears as intact fat cells. Further investigation on fat and water retention during heating revealed that over a wide range of attained chopping temperatures the level of extractable fat is significantly positive correlated ($P < 0.01$) with the amount of fat separation after heating. This implies that the integrity of fat cells in a sausage batter rather than the availability of released fat for emulsification determines the heat stability. Experiments with fat soluble dyes show substantial fat migration during the heating of unstable comminuted meat-fat-water mixtures.
The water-retention level after heating of canned meat-salt-water mixtures was determined as a function of both the chopping time and the attained temperature in the chopper. Optimal water binding during heating was achieved after 4 min comminution and remained constant over a chopping time range of 4 - 15 min corresponding to 0 - 18° C. Beyond 15 min the water retention gradually decreased as reflected in a steady increase in jelly formation during heating. Each specific water-retention level corresponding to a given batch with definite chopping history will be embodied in a complete batter prepared from the mixture by further comminution with back fat tissue.
The fat binding in the batters concerned is always correlated with the level of intact fat cells.
The results are discussed in the light of modern processing procedures in sausage manufacture.

F 1:2

Informations sur la capacité de rétention de l'eau et de la graisse dans des saucissons à bouillir

ERNST J.C. PAARDEKOOPER et BRYAN J. TINBERGEN
Centre Néerlandais pour la Technologie de Viande, Dépt. de l'Institut Central de la Nutrition et de l'Alimentation - TNO, Zeist, Pays Bas

Le mécanisme produisant la stabilité d'une pâte de saucissons à bouillir est encore peu connu. On lit fréquemment des hypothèses disant que la pâte de saucissons serait à considérer comme une émulsion de graisse et d'eau avec des protéines (de viande) fonctionnant comme émulsifiants. Cependant, des recherches microscopiques de ces saucissons avant et après chauffage ont montré une structure plus hétérogène, dans laquelle la graisse apparaît surtout comme une quantité de cellules intactes. De plus amples investigations concernant la rétention de la graisse et de l'eau dans un saucisson pendant le chauffage ont indiqué que dans des limites largement divergentes de températures de cutterage le niveau de la graisse extractible correspond d'une manière positivement significative ($P < 0.01$) à la quantité de la graisse séparée après chauffage. Ceci signifie que c'est l'intégrité des cellules de graisse dans la pâte plutôt que la présence de la graisse libérée pour l'émulsification, qui détermine la stabilité de la chaleur. Des expérimentations avec des colorants dissolvant dans la graisse montrent une migration considérable de la graisse pendant le chauffage de mélanges instables de viande, de graisse et d'eau. Le niveau de la rétention de l'eau après chauffage dans des mélanges de viande avec du sel et de l'eau était déterminé comme une fonction du temps de cutterage et de la température dans le cutter à la fois. La rétention d'eau optimale après un cutterage de 4 min reste constante durant un temps de cutterage de 4 à 15 min, qui correspond à 0-18° C. Après 15 min la rétention d'eau diminue graduellement, comme on peut constater de la formation continuelle de gelée pendant le chauffage. Chaque niveau de rétention d'eau correspondant à une charge hachée d'une certaine façon sera incorporé à une pâte préparée du mélange en le hachant encore plus avec du gras dorsal.
La rétention de la graisse dans la pâte en question correspond toujours au niveau des cellules de gras intactes. Les résultats seront discuté dans le cadre de la technologie moderne de charcuteries.

Новые сведения о связывании жира и воды в измельченных мясных продуктах.

Э.Й.Ц. ПААРДЕКООПЕР и Б.Й. ТИНДЕРГЕН
из отдела "Нидерландский центр мясной технологии" Центрального НИИ питания и пищи, Зейст, Голландия.

Механизм, действующий при термической стабилизации колбасных фаршей, полностью не разъясен. В письменности широко встречаются гипотезы, рассматривающие измельченные мясные фарши как эмульсии жира в воде при содействии мясных или добавочных белков. Однако, микроскопическая оценка смесей колбасных и "luncheon meat" типа до нагревания и после него, обнаружила более гетерогенную структуру, в которой жир главным образом находится в неповрежденных жировых клетках.
Дальнейшее исследование удержания жира и воды во время нагревания измельченных мясных изделий показало, что, в широком диапазоне конечных температур в мясорубке, уровень экстрагируемого жира имеет достоверную ($P \ll 0.01$) положительную корреляцию с количеством жира, выделенного после нагревания. Это свидетельствует о том, что целостность жировых клеток в колбасном фарше, а не жир, высвобожденный для эмульсификации, определяет термостойкость. Эксперименты при помощи жирорастворимых красок показали существенную миграцию жиров во время нагревания нестабильных измельченных смесей из мяса с жиром и водой.
Уровень удерживания воды по нагревании смесей из консервного мяса, соли и воды был определен в зависимости как от продолжительности рубки, так и от достигнутой внутри измельчителя температуры. Удерживание воды достигло оптимума через 4-минутное измельчение и осталось постоянным через промежуток 4-15 мин., т.е. 0-18°С соответственно; после этого, удерживание воды в вареной смеси постепенно падало, о чём свидетельствует непрерывный рост образования желе во время нагревания.
Уровень удерживания воды каждой отдельной составной со своей историей измельчения содействует в законченном фарше, изготовленном из смеси путем дальнейшего измельчения вместе со спинной жировой тканью.
Связывание жиров в данных фаршах всегда коррелируется с уровнем неповрежденности жировых клеток.
Результаты обсуждаются на фоне современной технологии производства колбас.

New information on fat and water binding in comminuted meat systems

ERNST J.C. PAARDEKOOPER and BRYAN J. TINBERGEN

Netherlands Centre for Meat Technology, Dept. of Central Institute for Nutrition and Food Research, TNO Zeist, the Netherlands

Introduction

The term "emulsion" to describe various comminuted meat systems is common. However, hardly any of these systems possess structures akin to that of a true and simple emulsion, i.e. one liquid phase finely dispersed in another. For emulsification in comminuted meat mixtures, fat has to be released from the adipose tissue cells and should be in the liquid state. The latter is not achieved at normal chopping temperatures. Furthermore, commercial food emulsifiers have been found to decrease rather than increase fat binding in meat products (Meyer et al., 1970). Increasing the concentration of dissolved proteins favours the heat stability of comminuted meat-fat systems (Acton and Saffle, 1970; Carpenter and Saffle, 1964; Inklaar and Fortuin, 1969) but is detrimental to emulsifying capacity (Acton and Saffle, 1972). More recent studies show that the heat stability of finished meat products, prepared in industrial choppers, also depend on chopping conditions (speed, time and temperature) and on the extent of breakdown of the adipose tissue cells (Evans and Ranken, 1975b). Increasing amounts of free fat in the mixture impair its heat stability (v.d. Oord and Visser, 1973). Microscopical examination of heat-processed sausages showed that under optimal conditions most of the fat cells are able to maintain their integrity despite intensive grinding and chopping. The fat released from damaged cells is dispersed in the meat mass in the form of small lumps which are generally much larger than the fat droplets in a real emulsion. Experiments, carried out by Evans and Ranken (1975) and Tinbergen et al. (1977) support this view. For the same reason, Brown and Toledo (1975) proposed to discontinue the use of the word "emulsion" and replace it by the term "batter".

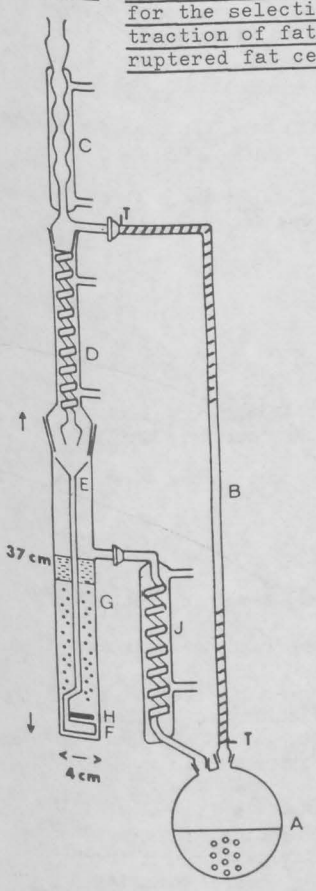
We found that the resistance of the fat cells to damage during comminution depended largely on the type of fat tissue and on its storage history (e.g. frozen vs. unfrozen). The question came up to what extent the fat cell damage is related to the fat separation after heating. Microscopical examination only allows a rough impression of the degree of fat cell damage. We report on a method for the selective extraction of the exposed fat from ruptured cells in the batter.

Materials and methods

Extraction of free fat from comminuted meat batters

Prepare a slurry of 6.0 g meat batter in 150 ml water. This has to be done with caution, e.g. by gentle stirring with a glass rod to avoid any damage to the fat cells due to excessive shear forces. Transfer the slurry quantitatively to the extraction chamber G of the all-glass percolation extraction apparatus (Fig. 1). Take care that the slurry remains 2-3 cm below the side arm which is connected to the cooler J by means of a ball joint. Insert the solvent collection tube EF, with a magnetic stirring bar H placed on top of the hollow glass disk F, into G. Mount the extraction chamber G into the apparatus.

Fig.1. Extraction apparatus for the selective extraction of fat from ruptered fat cells



Boil n-hexane in flask A. The vapour rises in tube B, which is heated by electric heating tape. The vapour condenses in the coolers C or D. The condensed hexane drops into funnel E which is connected to the glass tube debouching into disk F. The heating penetrates the meat batter slurry via the topside of F which is perforated with 1 mm wide holes. The magnetic stirring bar H keeps the slurry in motion and dissipates the hexane droplets. The hexane rises to the top of the aqueous phase. Fat-containing hexane builds up there until it reaches the side-arm and flows back, by way of the cooler J, into flask A.

Terminate the extraction after 3 h. Evaporate the hexane completely and weigh the remaining fat.

Sample material for extraction and fat separation after heating

Samples were from three groups of batters of different composition. Proximate analytical data are given in tables 1 and 2. All batters were prepared in a 40 l Kilia laboratory bowl chopper with three knives (rotation speed: knives 2500 rpm, bowl 20 rpm). For the three compositions various amounts of lean beef trimmings and pork back fat were used with equal levels of added water (13%) and salt (1.8%). To obtain marginal compositions with regard to heat stability, binders such as (poly) phosphates and starch were omitted. As can be seen in table 1 the degree of comminution was varied by different chopping times. This resulted in different final batter temperatures.

Table 1. Composition and chopping conditions of three batter groups

Batter group symbol (Fig.2)	protein %	moisture %	moisture protein ratio	chopping time range	ranges of attained chopping temperatures
▲	9	43	4.9	5 - 10 min	4° - 15° C
O	10	48	4.6	10 - 20 min	19° - 25° C
X	12	50	4.2	2 - 18 min	7° - 28° C

Fat separation and extractability

All batters were filled into 330 g cans and pasteurized for 60 min at 80 °C or sterilized for 60 min at 120 °C (Fo = 1.6).

Table 2. Total, free extractable and separated fat in batters or finished products

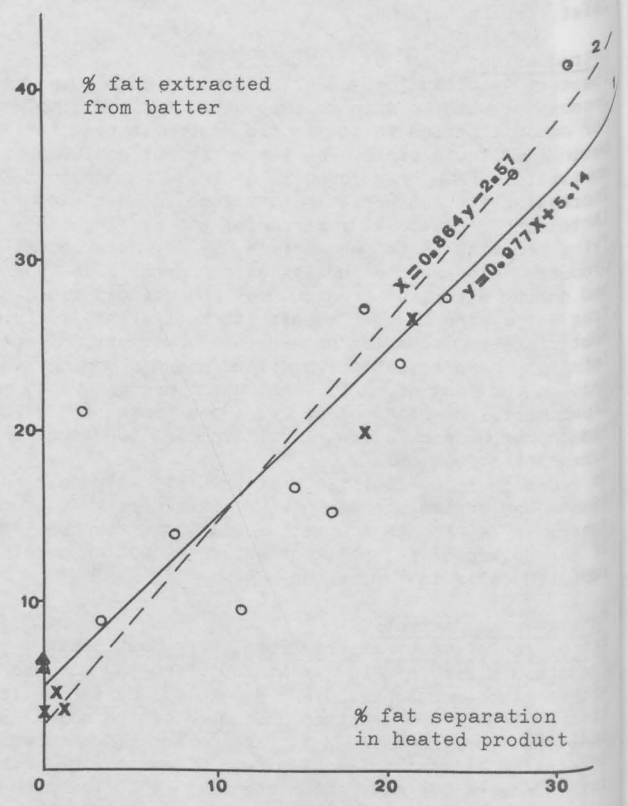
Nr.	% fat in composition	% fat sep.[1]	% fat extr.[2]	batter group symbol[3]
1	5.9	0.0	3.1	▲
2	35.5	0.0	3.3	X
3	5.9	0.0	6.1	▲
4	5.9	0.0	6.4	▲
5	35.5	0.3	4.0	X
6	35.5	0.5	4.7	X
7	39.6	2.5	21.0	O
8	39.6	3.5	8.7	O
9	39.6	7.8	14.0	O
10	39.6	11.8	9.4	O
11	39.6	14.8	16.6	O
12	39.6	17.0	15.0	O
13	39.6	18.3	24.0	O
14	35.5	19.0	20.0	X
15	39.6	19.0	27.1	O
16	39.6	20.9	23.8	O
17	35.5	22.1	26.2	X
18	39.6	24.0	27.7	O
19	39.6	27.6	35.0	O
20	39.6	31.0	41.2	O

1) mean % of fat separation from 5 cans heated 60 min at 80° C.

2) mean % of duplicate determinations

3) See Fig. 2

Fig.2. Correlation between the amounts of free extractable fat in a batter and fat separated after heating at 80°C



Preparation of meat-salt-water mixes

Meat-salt-water mixes (45:13:2) were obtained by chopping for various periods and subsequently heating in cans at 80° C. The jelly deposit was determined as % of total weight. The same unheated mixes were used to compose batters by further chopping with back fat (see below).

Batters from meat-salt-water prechops and back fat

Batters from the above mixes were obtained by chopping for different periods with back fat. The fat separation was determined after heating for 60 min at 80° C in 300 g cans.

Results

Fig. 2 shows the correlation between the percentages on sample weight basis of the free extractable fat and the separated fat after heating at 80° C. The regression equations are

$$Y_{\text{extr.fat \%}} = 0.977 \times_{\text{separated fat \%}} + 5.14 \quad (1)$$

and

$$X_{\text{separated fat \%}} = 0.864\ y_{\text{extr.fat \%}} - 2.57 \quad (2)$$

The correlation coefficient is 0.915 which is highly significant ($p < 0.001$). A similar correlation was found after sterilization at 120° C. The regression lines had practically the same slope, but were shifted to higher fat separation percentage:

$$Y_{\text{extr.fat \%}} = 0.922 \times_{\text{separated fat \%}} + 2.23$$

$$X_{\text{separated fat \%}} = 0.825\ y_{\text{extr.fat \%}} + 2.05$$

Microscopical examination of the batter residue after extraction revealed that all remaining fat was enclosed in intact fat cells that evidently had resisted the mild extraction treatment.

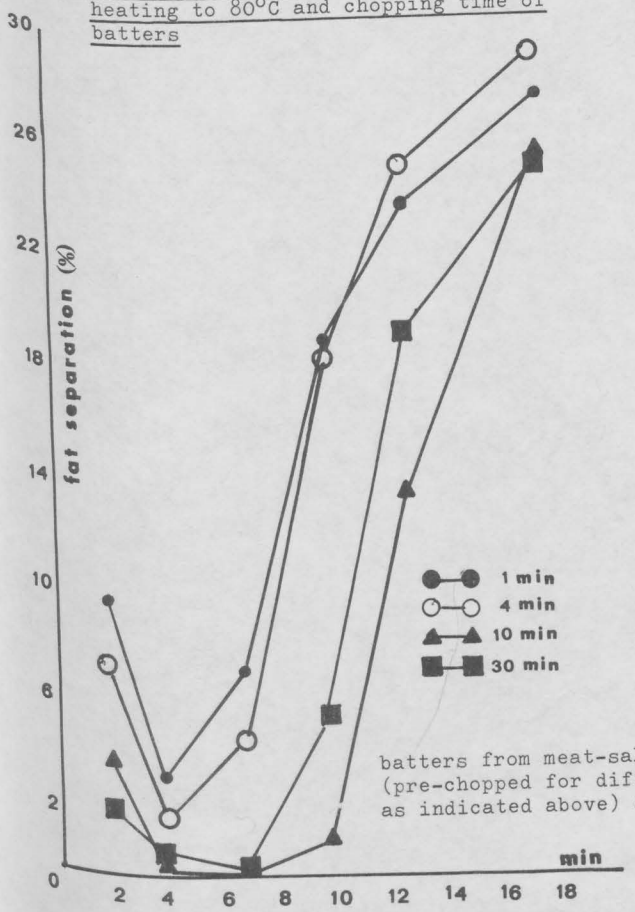
The results strongly support the concept that the fat separated upon heating was already present as free fat (i.e. excluded from damaged tissue cells) in the batter.

If fat and water binding and stability of the final product were dependent on the emulsification of the fat phase, one would expect that a higher degree of fat cell damage favours the availability of emulsifiable fat and ipso facto the heat stability of the product. This is opposite to what we actually found.

Our results indicate that the integrity of the fat cells in the processed meat batter rather than the availability of released fat for emulsification determines its heat stability.

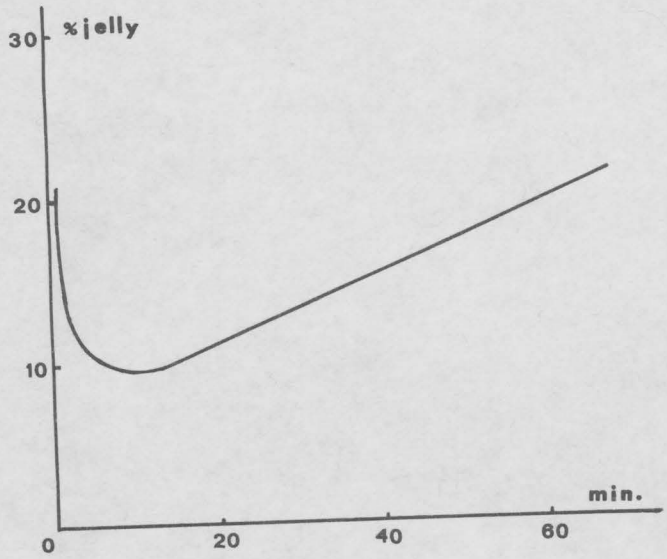
In fig. 3 the jelly deposit as a function of the chopping time of meat-salt-water mixes is shown. At the experimental conditions chosen a chopping period of 4 min results in optimal water binding during subsequent heating. Comminution beyond 15 min leads to a steady decrease of the heat stability of the protein-water matrix. Fig. 4 shows the relation between the percentage of separated fat and the chopping time of a batter.

Fig.4. Relation between fat separation after heating to 80°C and chopping time of batters



batters from meat-salt-water mixes (pre-chopped for different periods as indicated above) and backfat

Fig.3. Jelly formation in heated meat-salt-water mixes as a function of the chopping time



The persistence of the pre-chopping history of the meat-salt-water mix is clearly demonstrated. Although every batter reaches a point of minimal fat separation somewhere in the range of 4 - 8 min chopping, the level of this minimum depends on the heat stability level of the protein-salt-water mix predetermined by the pre-chopping procedure. This indicates that the fat stability in a heated batter is the resultant of the effects of the protein-water matrix formation during pre-chopping and the destruction of fat tissue cells on further comminution.

References

Acton, J.C. and Saffle, R.L. 1970. Stability of oil in water emulsions I. Effects of surface tension, level of oil, viscosity and type of meat protein. J. Food Sci. 35: 852

Acton, J.C. and Saffle, R.L. 1972. Emulsifying capacity of muscle protein, phase volumes at emulsion collapse. J. Food Sci. 37: 904

Brown, D.D. and Toledo, R.T. 1975. Relationship between chopping temperatures and fat and water binding in comminuted meat batters. J. Food Sci. 40: 1061

Carpenter, J.A. and Saffle, R.L. 1964. A simple method of estimating the emulsifying capacity of various sausage meats. J. Food Sci. 29: 774

Evans, G.G. and Ranken, M.D. 1975a. Fat cooking losses from non-emulsified meat products. J. Food Technol.10:63

Evans, G.G. and Ranken, M.D. 1975b. Cooking losses in meat products. Part III.Comminuted mixtures of lean beef and pork fat. B.F.M.I.R.A. Research Reports No. 219, Food R.A., Leatherhead, England

Inklaar, P.A. and Fortuin, J. 1969. Determining the emulsifying and emulsion stabilizing capacity of protein meat additives. Food Technol. 23: 103

Meyer, J.A., Brown, W.L., Giltner, M.E. and Guinn, J.R. 1964. Effect of emulsifyers on the stability of sausage emulsion. Food Technol. 18: 1796

Oord, A.H.A. v.d. and Visser, P.R. 1973. Properties and distribution of fat in minced meat products (in German). Fleischwirtschaft 53: 1427

Tinbergen, B.J., Biert, M. v. and Pfrommer, G. 1977. Binding and heat stability in comminuted meat products. III Type and pre-handling of fat tissue (in Dutch) Research Report Nr. 5235 of the Central Institute for Nutrition and Food Research TNO, Zeist, Holland.