On the water-binding capacity of the ingredients of cooked sausage

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The significance of the various ingredients in water binding and structure formation in a heated sausage emulsion is not easily studied in terms of practical requirements in view of the complexity of the system, and is thus incompletely known. The aim of the method used in this study is to reproduce as closely as possible the conditions of sausage manufacture in the laboratory. The method involves the preparation of 250 g batches of emulsion with different recipes using an efficient kitchen cutter. The emulsion is injected into a 42 mm collagen casing before being cooked and cooled in the normal manner. The emulsions contain an excess of water, and the water binding is calculated by weighing following removal of the water and jelly released beneath the casing after cooking. In consistency determinations the emulsions do not contain excess water. This method allows one person to prepare more than ten different sausages per day at low cost.

As the amount of water added was increased the water-binding capacity of the meat first showed a slight increase for a constant amount of salt, but at a certain point began to decline. If the amount of salt used was added in proportion to the water added, the water-binding capacity continued to rise more markedly and for a longer time than when the amount of salt was kept constant. As the amount of water added was increased, the sausage became softer. As the amount of fat added increased, the water-binding capacity of the red meat increased slightly for a constant amount of salt. When the salt content was kept constant the increase in water-binding capacity was slightly greater. An increase in the fat content improved the consistency.

The relative water-binding capacities (g water/ g ingredient) of meat, connective tissue, pork skin, powdered milk and potato flour fell hyperbolically as the amount of the ingredient increased.

Über das Wasserbindungsvermögen der Brühwurst-Rohmaterialien

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Die Bedeutung der einzelnen Rohstoffe für die Wasserbindung und Gefügebildung im erhitzten Brät ist in diesem komplexen System, was die Belange der Praxis betrifft, schwer zu untersuchen und demzufolge noch ungenügend bekannt. Mit dem in dieser Arbeit angewandten Verfahren wurde versucht, die praktische Wurstherstellung unter Laborverhältnissen anzugehen. Bei besagtem Verfahren werden mit einem leistungsfähigen Küchenkutter 250-g-Brätposten nach verschiedenen Rezepten hergestellt. Das Brät wird in 42-mm-Kollagen-Wursthülle gefüllt sowie auf herkömmliche Weise gebrüht und gekühlt. Die Brätposten sind überschüttet, und die Berechnung der Wasserbindung erfolgt an Hand von Gewichtsbestimmungen nach vorherigem Entfernen der unter den Hüllen der gebrühten Würste angesammelten Wasser- und Geleemenge. Bei der Konsistenzbestimmung ist das Brät nicht überschüttet. Nach diesem Verfahren können von einer Person bei geringen Kosten über zehn verschiedene Würste pro Tag hergestellt werden.

Mit zunehmendem Wasserzusatz stieg das Wasserbindungsvermögen des Fleisches bei konstanter Salzmenge zunächst etwas an, begann aber dann von einem bestimmten Punkt an abzunehmen. Wurde die Salzmenge proportional zum Wasserzusatz erhöht, so war ein kräftigerer und längerer Anstieg des Wasserbindungsvermögens als mit konstanter Salzmenge zu verzeichnen. Mit zunehmendem Wasserzusatz wurde die Wurst weicher. Mit zunehmendem Fettzusatz stieg das Wasserbindungsvermögen des Muskelfleisches bei konstanter Salzmenge leicht an, und bei konstantem Salzgehalt lag dieser Anstieg etwas höher. Durch Steigerung des Fettgehaltes wurde eine bessere Konsistenz erzielt.

Das relative Wasserbindungsvermögen (g Wasser/g Rohstoff) von Fleisch, Bindegewebe, Schwarte, Milchpulver und Kartoffelmehl ging [illegible] achsendem Gehalt des Rohstoffes hyperbolisch zurück.

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La capacité de rétention de l'eau des matières premières du saucisson à bouillir

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L'importance des différentes matières premières dans la fixation de l'eau et la formation de la structure de la pâte de saucisson est, dans un système aussi complexe et dans la perspective des besoins pratiques, difficile à apprécier et par conséquent incomplètement connue. Par le procédé employé au cours de cette étude, on s'est efforcé de réaliser dans le cadre du laboratoire une approche de la fabrication pratique du saucisson. Le procédé permet de préparer au moyen d'un cutter de cuisine efficace des portions de 250 g de pâte de saucisson selon diverses recettes. La pâte est injectée dans un boyau au collagène de 42 mm de diamètre puis cuite et refroidie de façon conventionnelle. Les pâtes sont additionnées d'un excès d'eau et la rétention de l'eau est évaluée par la pesée de l'eau et de la gelée qui se sont séparées sous la peau après la cuisson. Pour l'appréciation de la consistance, les pâtes ne sont pas additionnées de cet excès d'eau. Par ce procédé, une personne seule est capable de préparer plus de 10 saucissons différents en une journée, à faibles frais.

La quantité d'eau ajoutée augmentant, la capacité de rétention de l'eau de la viande croît d'abord, avec une quantité de sel constante; mais elle retombe à un certain point. Si le sel est ajouté en quantité proportionnelle à l'eau ajoutée, l'accroissement de la capacité de rétention se prolonge plus fortement et plus loin qu'avec une quantité de sel constante. La quantité d'eau ajoutée augmentant, le saucisson mollit. La quantité de graisse ajoutée augmentant, la capacité de rétention de l'eau de la viande rouge avec une quantité de sel constante croît quelque peu; et, la teneur en sel étant maintenue constante, l'accroissement est quelque peu supérieur encore. L'augmentation de la teneur en graisse améliore la consistance.

La capacité relative de rétention de l'eau de la viande, des tissus conjonctifs, de la peau de porc, du lait en poudre et de la farine de pomme de terre (en grammes d'eau par gramme de matière première) décroît hyperboliquement lorsque croît la teneur en matière première.

О свойствах связывания воды сырья для вареной колбасы

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Значение различных видов сырья в связывании воды, а также в оформлении структуры нагретого колбасного фарша в настоящей комплексной системе, из точки зрения практики, является трудно изучаемым и следовательно недостаточно исследованным. С помощью метода, используемого в этом исследовании, стремились к приближению изготовления колбасы на практике при лабораторных условиях. Настоящим методом приготовляют с помощью эффективного кухонного кутера 250-граммовые партии фарша по разным рецептам. Фарш шприцывают, как правило, в 42 мм:ую коллагеновую кишку, варят и охлаждают. Фарши с излишным содержанием воды, при чем связывание воды подсчитают на основании взвешиваний путем удаления выделенных после варки под оболочку воды и желе. При определении плотности в фаршах не наблюдается излишнее содержание воды. С помощью настоящего метода один человек с небольшими расходами может изготовлять свыше 10-ти разных сортов колбасов в день.

По мере повышения содержания воды сначала способность связывания воды немного возрастала со стандартным количеством соли, но достигнув определенной точки, способность связывания воды начала падать. Если количество соли добавляли пропорционально с водой, подъем способности связывания воды продолжался еще сильнее и дальше, чем не изменяя количества соли. При повышении содержания воды колбаса смягчалась. При повышении содержания жира, способность связывания воды красного мяса с обыкновенной дозировкой соли немного возрастала, а при неизменном содержании соли рост был немного больше прежнего. Повышение содержания жира улучшило плотность.

Относительная способность связывания воды (г воды/г сырья) мяса, соединительной ткани, свиной кожи, молочного порошка и крахмала понижалась гиперболически при возрастании содержания сырья

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A great deal of research has been carried out into the water and fat-binding capacity of meat. The functional characteristics of the other ingredients used in the preparation of sausage have also been extensively investigated using various types of laboratory tests. However, cooked sausage is a highly complex mixture comprising several different phases, extenders and additives, making it difficult to study the structure of this type of sausage in the laboratory.

In this study the small sausage method (PUOLANNE and RUUSUNEN 1978) was used; this involves preparation of the sausage on a small chopper and stuffing, cooking and cooling them in the normal manner. Using this method one person can easily prepare 10-12 different sausages per day. This method is slightly closer to the actual manufacture of sausage than is the purely laboratory method, although a number of simplifications in the test arrangements have to be made compared with industrial sausage manufacture.

Material and methods

The emulsions were prepared as follows: pre-homogenised lean meat was chopped in a kitchen chopper (Moulinex Moulinette, manufactured by Moulinex, France) for c. 15 sec. with salt, followed by the addition of pork, phosphate and the gradual addition of water (ice). The final temperature of the emulsion was 20°C. When ready the emulsion was stuffed into a 45 mm collagen casing (manufactured by Naturin-Werke, Weinheim, FRG), cooked for 30 min. at 74°C in a steam chamber and cooled in an ice-water bath.

The basic mixture contained 40 g of shoulder of beef (fat content < 10 %) taken from a young animal, 40 g of pork (fat content c. 60 %), 2 % salt, 0.3 % phosphate and water (ice). The composition of this mixture was varied with respect to the ingredients according to the test arrangements. When determining the consistency, a smaller amount of water was added or else 2 % potato flour was used so that the release of water did not affect the results.

Other ingredients were pork fat (fat content c. 90 %), the connective tissue membrane located on the *longissimus dorsi* muscle (fat content c. 2 %) taken from a young cow, pork skin (fat content c. 5 %), non-fat dry milk (protein content 36 %) and potato flour (starch content 80 %). The connective tissue membrane and pork skin had been mixed with ice (1 : 1) and ground fine by passing it through a colloid grinder (Stephan Microcut, manufactured by Stephan and Söhne, Hameln, FRG).

After cooling the sausages were skinned on the following day and the water and jelly present on the surface removed before weighing. The sausages were weighed at the various stages of preparation and the water-binding capacity determined on the basis of the difference between the weights of raw emulsion and the ready sausage.

The results were reported as follows:

1. The amount of water bound (WB) g water/100 g meat (lean meat + pork).
2. The relative water-binding capacity (RWBC) g water/g ingredient for each of the ingredient contents being investigated. The result was obtained by subtracting the amount of water bound by the control sausage from that bound by the sausage under study and dividing the difference by the amount of ingredient being studied.
3. The consistency in kg, by applying lateral pressure to the sausage using the piston of an Instron device (manufactured by Instron Ltd., High Wycombe, England).

Each experimental series was repeated 3-10 times.

Results

Amount of water added (Fig. 1). The addition of 80-200 g of water per 100 g of meat caused an initial increase in the amount of water bound that was almost directly proportional to the

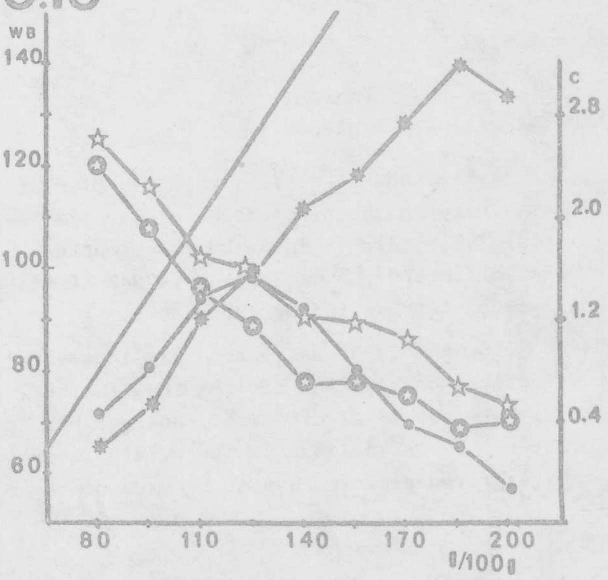

Fig.1. The influence of the amount of water added on the amount of bound water (WB ✵●) and consistency (C✪☆). The amount (●☆) or the concentration (✵✪) of salt and phosphate constant.

amount of water added. This was due to the fact that with smaller amounts of water the meat still had some of its water-binding capacity and so almost all the water was bound. The difference between the actual water binding and the straight line depicting the amount of water added is due to the loss in weight and also to the fact that a little water is always released from the sausage under the casing. When the amounts of salt and phosphate were constant the curve showing the amount of bound water departed from the direction of the straight line showing the amount of water added at the point 100 g water/100 g meat. After this point the water binding continued to increase slightly, finally turning into a decrease as the amount of water added continued to increase. When the salt and phosphate concentrations were kept constant, the water binding continued to increase considerably longer. The water binding began to fall at the point where the water added was 185 g/100 g of meat. Before this there was quite a large amount of water separated beneath the casing, as seen from the difference between the amount of water added and the water-binding curve. Initially the consistency decreased almost linearly as water was added, but when the water-binding capacity began to decrease the consistency remained almost constant. This is due to the fact that following separation of water the water remaining in the emulsion determines the consistency.

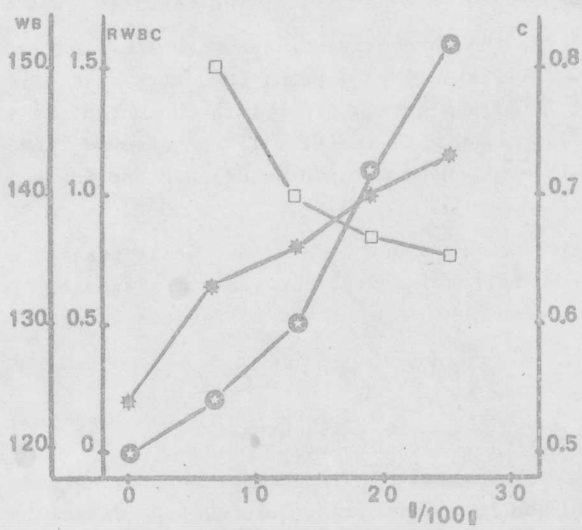

Fig.2. The influence of the amount of additional meat on the amount of bound water (WB ✵), relative water-binding capacity (RWBC □) and consistency (C✪). The amount of water added 170 g/100 g meat for WB or 120 g/100 g meat and 2 % of potato flour for C.

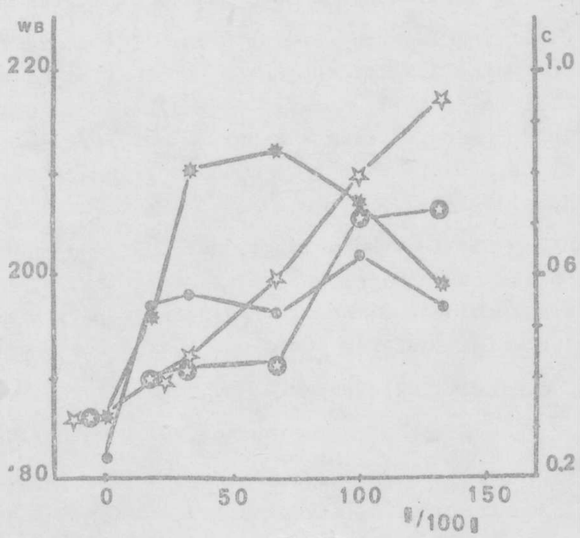

Fig. 3. The influence of the amount of fat added on the amount of bound water (WB✵●), and consistency (C✪☆). The amount (●☆) or the concentration (✵✪) of salt and phosphate constant. The amount of water added 256 g/100 g of lean meat.

Meat content (Fig. 2). As the amount of lean meat in the emulsion was increased and the salt and phosphate concentrations kept constant the amount of bound water was observed to undergo an initial steep increase, which later became slightly less marked. Calculating the RWBC for the increase in the amount of meat shows that the RWBC falls hyperbolically as a function of meat added. The consistency increased almost linearly as a function of the amount of meat added.

Fat content (Fig. 3). As the amount of fat added was increased, the water-binding capacity of the lean meat increased slightly for a constant amount of salt. When the salt content was kept constant the increase in water-binding capacity was slightly greater. As far as fat was concerned the RWBC was not calculated. An increase in the fat content improved the consistency. Increasing the amount of salt added seemed to make the consistency softer.

Content of connective tissue and skin (Fig. 4). In these experiments the salt and phosphate concentrations were kept constant. Initially the connective tissue bound a small amount of water but for larger amounts of water the increase in water binding was small and the RWBC thus decreased as the amount of connective tissue added increased. The consistency improved linearly as the content of connective tissue increased. Skin had the same effect as connective tissue.

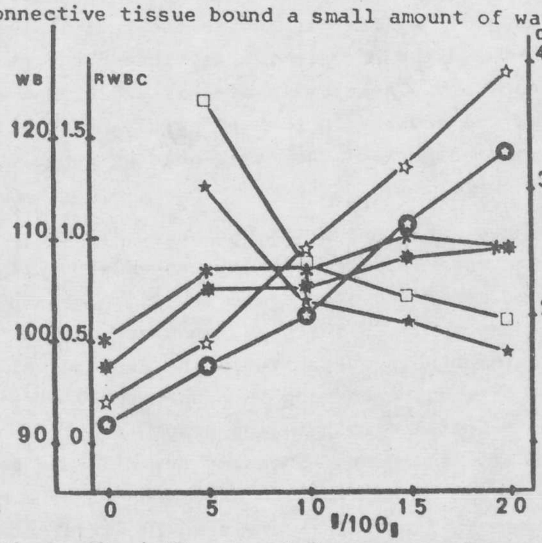

Fig.4. The influence of the amount of connective tissue (✱□✪) added or pork skin (✱★☆) on the amount of bound water (WB✱✱), relative water binding capacity (RWBC □★) and consistency (C✪☆). The amount of water added 126 g/100 g meat.

Non-fat dry milk content (Fig. 5). Non-fat dry milk had the same effect as the other ingredients: there is an initial increase in water binding which later slows down. The RWBC is thus also hyperbolic. The consistency improved almoust linearly as the content of non-fat dry milk increased. The sausages with higher levels of non-fat dry milk were non-elastic, however. The amounts of salt and phosphate were kept constant in this test. The amount of water added in this test was extremely high (200 g/100 g meat). As a result of this the RWBC value is too high in terms of actual production since the control sausages broke up (see "Amount of water added").

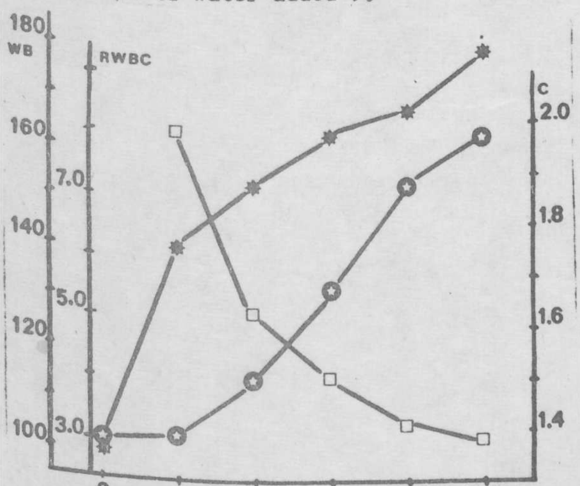

Fig.5. The influence of the amount of non-fat dry milk on the amount of bound water (WB ✱), relative water-binding capacity (RWBC □) and consistency (C✪). The amount of water added 200 g/100 g meat for WB or 100 g/100 g meat for C.

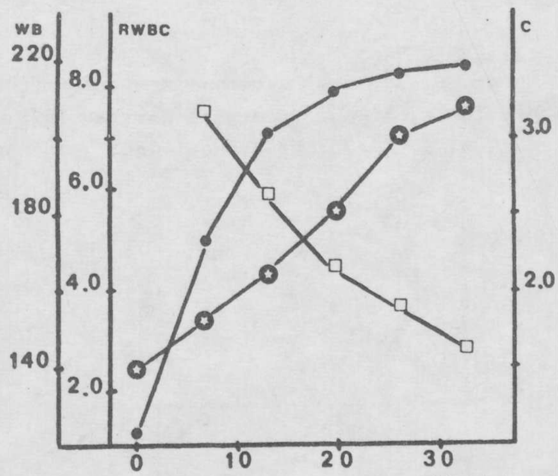

Fig.6. The influence of the amount of potato flour on the amount of bound water (WB ●), relative water-binding capacity (RWBC □) and consistency (C ✪). The amount of water added 228 g/100 g meat for WB or 100 g/ 100 g meat for C.

Potato flour content (Fig. 6). Potato flour was highly effective in binding water, and in larger quantities bound almost all the water. The curve showing relative binding by potato flour was also hyperbolic, even in the area where not all the water was bound. Initially the consistency improved linearly with the increase in the potato flour content, but in the area where the emulsion contained 25 g potato flour the increase slowed down slightly. The amounts of salt and phosphate were constant in this test. Like with non-fat dry milk the amount of added water was extremely high causing unrealistic high RWBC-value.

Discussion

Increasing the amount of water added to some extent reduces the water-binding capacity of the meat by diluting the ionic strength of the sarcoplasm. If the salt content is kept constant the water-binding capacity increases as the amount of water added increases (HAMM 1957). The results of the present study corresponded well with the above results obtained by Hamm from raw meat using the filter paper method. Increasing the amount of fat at first seemed to improve the water-binding capacity, but no increase in water-binding capacity was seen for larger amounts of fat. SCHUT (1978) suggested that the improvement in the water-binding capacity by fat was due to the fact that the lipids, which to some small extent penetrate between the protein chains, loosen the protein network and thus increase the water-holding capacity. The results of this experiment also provided grounds for assuming that the salt added to the sausage is perhaps partly mixed with the fat phase since increasing the amount of salt does not affect the water-holding capacity as much as it does in conjunction with the addition of water.

The other ingredients had basically the same effects in combination on water binding. The increase in water binding was relatively greatest for the first level of additives, but decreased for successive levels. The RWBC thus decreased hyperbolically as the additive increased. This may be important when using linear programming, since this assumes that the water-binding capacity is the same for all levels of ingredients, in which case the graph of the relative binding is a horizontal straight line. According to this investigation a horizontal straight-line graph is only approached with rather high levels of additives. As far as the extenders - non-fat dry milk and potato flour - are concerned the relative binding in sausage lies within an area bounded by a curve; however, this may also apply to meat, especially when binding values are used in different types of sausages for different proportions of extenders and with different amounts of water. This investigation showed indirectly that it is very difficult to determine precisely the binding values for use in the commercial production of sausages. It should, however, be borne in mind that in the industrial manufacture of sausage the amounts of water added are not usually high enough for much water to separate. The main difficulty is to obtain an acceptable consistency to say nothing of other organoleptic properties and nutritional value.

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