Meat Processing: Cooked Products.

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Cooked meat products are generally marketed after they were heat-processed within the production facility. The application of heat to these products as a finishing production step, and before they are sliced or packaged, is necessary, to make them easily digestible, to inactivate enzymes (e.g. lipasas) as well as microorganisms, and to give them a specific colour, taste and consistency. According to the technological procedures during their production, cooked meat products fall into two groups: 1) products made with preheated meats, 2) products from raw meats. Examples for sausages belonging to the first group are liver sausage, blood sausage and products in/with jelly, gelatine, or in/with heated and more or less finely comminuted pig skin. In Germany they are called "Kochwürste" (cooked sausages). Examples for products belonging to the second group are cooked hams and formed and/or restructured cured and cooked meats, as well as sausages like frankfurters, wieners, bologna, mortadella. These last sausages are in english called cooked sausages. In order to distinguish them from sausages belonging to the first group, they are called "Brühwürste" (scalded sausages) in Germany. The finishing heat processing of products belonging to the first group is traditionally done in such a way, that the temperatures in the centre of the products are between 75 to 80 °C. The core temperatures in cooked hams and cooked sausages are between about 65 °C (some cooked hams) and 70 to 75 °C. The necessity to heat sausages belonging to the first group to temperatures, which are about 5 - 10 °C higher than those of sausages belonging to the second group, and to preheat most of their tissues before they are processed further, arises, because the raw materials for products of the first group (among others pig skin and intestines like liver) are often more heavily contaminated with vegetative microorganisms than those for products of the second group.

With respect to the appearance of the cooked products the attention of the consumer is first attracted to the colour of the fresh cut. The pink colour of the sausages or of the meat pieces is brought about by nitrite. Products without nitrite are either grey or, if fat meats are utilized and no vacuum is applied during the comminution of the sausage batters, appear more or less white. Nitrite does not only give or stabilize the cured (pink) colour. In addition to that, the nitrite, and not NaCl, imparts the cured flavor, it shows an antioxidative activity and it acts antimicrobially. 30 to 50 ppm (mg/kg) of nitrite are necessary for the colour to develop, and 20 to 40 ppm of nitrite give rise to the cured flavor (WIRTH, F., 1984). Cured and cooked products are in Germany generally produced with ascorbic acid or ascorbate to speed up, support and stabilize the colour generating mechanisms. The minimum amount of nitrite, which is necessary to retard oxidative rancidity of cooked meat products has not yet been determined experimentally. In heated meat products the antimicrobial action of nitrite must not be overestimated. It has to be seen in connection with further factors or hurdels, which influence the microbial growth in and on cooked products. The main hurdels are the operating temperatures and times during the heating process and the storage temperature of the finished product. Further hurdels of practical importance are the water activity and the pH-value of the heated product. SCHMIDT and LEISTNER (1991) recently discussed the possibility to minimize the Listeria problem by an addition of sodium acetate to the product and by an inoculation of prepackaged cooked products during the slicing process with Lactobacilli, which produce bacteriocines and no greater amounts of lactic acid.

If cooked meat products are not cooked in impermeable casings, they are generally smoked. The main reasons for the application of wood smoke are, that it gives the product surfaces a smoked colour and the whole product a smoky flavor. The direct antimicrobial effects of constituents of the wood smoke must not be underestimated. They present a protection against a fast microbial growth on the product surface or casing. This is of special importance for sausages which are coated with a layer of glycerides after the heating and smoking process. Such a coating is applied for example to whole liver sausages in order to exclude the negative influences of dehydration and discoloration on the product appearance and eating quality. With respect the temperatures with which the products are smoked three smoking methods must be distinguished (MÜLLER, 1988). These are cold smoking (between 12 and 25 °C), warm smoking (between 25 and 50 °C) and hot smoking (between 50 and 85 °C). Cooked sausages, like liver sausage and blood sausage, are smoked cold. The smoking takes place after the sausages are heated and after a cooling step to core temperatures of about 10 °C. The smoking time may be as long as 6 hours. With such long smoking times the temperatures of the wood smoke should be lower than 20 °C in order to avoid the germination of spo of Clostridium and Bacillus. Some delicatessen are not heated, but only smoked warm. Examples are black smoked cured meats from Bavaria and Austria. In these cases a smoke with temperatures of only about 50 °C is applied for up to 6 hours. In the temperature range of the product between 30 and 40 °C meat enzymes are activated, and these smoked meats become particularly tender. After temperatures between 40 and 50 °C are reached, the meat proteins are partially denaturated. If cool sausages, cooked hams and other cured, cooked meats shall be smoked, the following procedure is used. Before the smok is done, the product surfaces are dehydrated in the smoking chamber at temperatures between 40 to 60 °C and relative humidities around 50 %. Because of the relatively high temperatures, not only a drying takes place, but the nitrosation of the meat pigments by NO, generated from nitrite, is speeded up. After that a hot smoke with temperatures, which depend on the method of the smoke generation (MÜLLER, 1984), and are between 60 to 70 °C is applied. The relative humidities in the smoking chamber are between 50 and 85 %. The smoking time may be highly variable and depends on the aimed intensity of the smoked colour and flavor, the method of smoke generation and the type of the smoking chamber. After that a cooking process takes place. The temperatures during the finishing cooking process are not not only determined by hygienic considerations, but often more by the goal, to have a cooking loss as low as possible. Some cooked sausages are dried after they are smoked and cooked. These are the "Brühdauerwürste", which show, after packaging under vacuum, a shelf life of up 18 months without refrigeration (WIRTH, 1979). These are examples for sausages, which are made shelf stable by a reduction of their water activity (a_W-SSP) (LEISTNER, 1987). Their water activity is lower than 0.95 and may be as low as 0.80 (STIEBING 1984).

Cooked sausages of the liver sausage or blood sausage type or products in/with gelatine and frankfurter type cooked sausages, which may contain more or less coarsely comminuted pieces of meat within a finely comminuted batter, should not fall apart on heating and should show a only minimal fat and/or water separation under their casing or in pores of the cut surfaces. Cured, cooked meats should have no considerable weight loss in comparison with their green weight and shall not apart on slicing. In addition to that frankfurter type sausages must show a typical bite on eating. That these requirements can met, depends on the existence of a matrix, which immobilizes the other constituents of the product and/or causes its cohesion

The probably most effective way to do this is to produce a gel from gelatine or from one of its original materials, the heated and comminuted pig skin, first. Then the rest of the product components is mixed with this matrix while it is still warm and can coat the materials which are to be immobilized. After that the mix is filled into suitable casings and cooled, so that the gel sets. Exactly that is done during the production of some products in/with jelly. The jelly immobilizes the added materials. These are cooked meats, spices, often cereals, like corn, paprica, and even eggs. Some of these mixes are cooked after they are filled in casings. The matrix of these products must not be transparent, it may be opaque. A white colour arises, if the heated pig skin comminuted together with fat meats. In this case, the matrix does not only stabilize the coarse constituents because it solidifies sets, on cooling, but holds the fat in a suspended form within the body of the matrix. Blood sausages and liver sausages are always heat processed after their matrx has been built. The matrix of blood sausages consists of gelastinized pig skin and raw blood, the proteins of which probably denature coherently during the finishing heating process. The matrix of liver sausage is raw liver. On heating of the sausage, the liver proteins denature coherently. The matrix must have the possibility to coat the particles, which it must suspend, in order that these are not set free or separated during the heating process. Therefore the precooked tissues are mixed with the precooked pig skin and the raw blood (blood sausage) or the raw liver (liver sausage) before the mix is filled into casings and cooked. The tissues, except the liver, for liver sausage must be preheated to at least 65 °C. The addition of raw liver, comminuted or not, to these preheated tissues takes place after their temperature is lower than about 60 °C. If, on the addition of liver, the cooked tissues show a higher temperature than about 60 °C, a part of the liver proteins may become denatured and loose their matrix building ability. The mixing and comminuting process for finely comminuted liver sausage should be ended at batter temperatures of no less 35 °C. If this temperature regime is followed, no massive fat or water separation arises on heating of the sausage. Of cause not all combinations of precooked fat meat, precooked lean meat and raw liver are heat stable. A corresponding phase diagramm has been worked out (HAMMER, 1988).

The matrix of cooked sausages and of cured, cooked meats is made up from salt soluble swollen meat proteins. To make these meat proteins swell, an addition of salt and, for most of the commercial products, of water is necessary. To guarantee a stable matrix, which is able to hold the water and more or less big pieces of meat on heating, a destruction of muscle cells and an extraction of salt soluble proteins out of them takes place. Even whole cooked hams, with green weights of several kilogramms, are tumbled together with water and salts in sophisticated tumbling mashines (MÜLLER, 1991 a, MÜLLER, 1991 b), in order get cooked hams of a weight, which is comparable to the weight of the green hams. According to the size of the tissues or tissue particles, which must be immobilized, the necessary muscle cell destruction is variable. The matrix for most cooked sausages is prepared in a bowl chopper, and raw lean meat is in a first step intensively comminuted together with salts and ice. At temperatures of ± 0 to 2 °C the fat meat (generally pork) is added to this matrix, and the comminution of the cooked sausage batter is continued. The batter is ready for the addition of coarse meats or for filling and heating, as soon as particles of the fat meats are no longer visible. If precooled tissues (± 0 to 5 °C) are taken, the batter has then a temperature of generally no more than 12 °C. This is the recommended end temperature for the chopping process of cooked sausage batters (AMBROSIADIS and WIRTH, 1984).

Knowing the technological mechanisms for the production of heat stable matrices, its can be seen, that salts are not necessary for products belonging to the first of the above mentioned groups. This is of special importance, because there probably exists a connection between high blood pressure in man and the consumption of NaCl. The amount of salt, which is eaten per day with the diet, amounts to 8 - 15 g per day. About 20 % of this stem from meat products. The necessary uptake of NaCl is 2 to 5 g NaCl per day. Therefore a challenge for the technologist is, to give hints for the production of meat products with a salt content as low as technologically possible. Without the addition of salts liver- and blood sausages as well as products in/with jelly show sodium contents between 100 and 200 mg/100 g (WIRTH, 1989). The livery or bloody or bland flavor of these products can be overcome by the addition of higher than normal amounts of spices, e.g. herbs. These products can show a shelf live of up to 4 weeks, if they are heated to temperatures of 80 °C or higher and if they are distributed and stored at temperatures between 0 and 5 °C. Cooked sausages and cured cooked meats show in Germany a NaCl-content of about 2 %. The limiting factor for a salt reduction in these products is the water holding capacity of the meat proteins, which build their matrix. Cooked sausages with 0.9 % NaCl in the recipe show a low sodium content of only 500 mg/100 g (WIRTH, 1989). On heating they separate no greater amounts of fat and/or water, if pyrophosphate is used during the batter production. After heating to 75 °C and holding the products at ± 0 to maximally 5 °C, the distribution time of these low salt cooked sausages may be as long as 4 weeks. Cured cooked meats with a heating gain between 90 to 95 % can be produced with 1.1 % salt. They show then a sodium content of about 500 mg/100 g. After cooking to 65 or 68 °C their shelf live is about 2 weeks, if they are held at temperatures between ± 0 to 2 °C.

Public health considerations point to a second challenge: the reduction of the fat content of meat products. Cured cooked meats and products in/with jelly can be produced without the addition of fat meats. Therefore their analytical fat content is between 5 and 15 %, their energy content between 100 and 200 kcal/100 g. For finely comminuted liver sausages and cooke sausages the utilization of fat meats is necessary to acchieve a satisfying eating quality (texture, juiciness, flavor) (WIRTH, 19 After adding water instead of part of the fat meats, and/or pig skin or tendons, and/or blood plasma and pyrophosphate (no for liver sausage; here the salt soluble and swellable meat proteins are heat denatured, when the matrix of liver proteins form cooked sausages with a fat content of minimally 10 % and liver sausages with 15 % fat can be produced, which show a good eating quality.

The fat phase of liver sausages and of cooked sausages must not come from animal fat. It may totally or partially consist unsaturated oils of plant origin. Sausages with plant oils can be heat stable without the addition of phosphates or blood plasm or other proteins, like caseinate (HAMMER, 1991). A total or partial substitution of fat meats by unsaturated vegetable oils me the requirement, to consume more unsaturated fatty acids in order to lower the risk of a coronary heart disease.

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