MICROBIAL STABILITY OF LOW FAT AND/OR LOW SALT MEAT PRODUCTS

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I. Introduction

If for nutritional reasons the fat and/or salt content of meat products are reduced, most likely their microbial stability and safety will be diminished. Many different fat replacers and salt (i.e., sodium) substitutes are under discussion or are already applied. However, quantitative data about their influence on the microbial stability of meat products are lacking. Therefore, the effect of these ingredients must be measured and evaluated by taking important stability factors (hurdles), such as aw, pH, Eh, preservatives, and the microstructure of the foods into consideration as well as the potential pathogenic and spoilage microorganisms inherent to muscle foods. The emerging quantitative data could become the basis for the microbial stability management of novel low fat and/or low salt meat products. In this contribution some of the relevant aspects are summarised.

II. Reduced Fat and/or Salt Content in Meat Products

Fat and common salt perform fundamental technological, microbiological and sensory functions in muscle foods and, therefore, many measures have to be taken to make up for any reduction in the content of these essential substances (Wirth, 1991). By using approriate technologies a minimum fat content in the finished products of 10%, 15%, and 20-30% is feasible in emulsion-type sausage, liver sausage, and fermented sausage, respectively. Thus, the possible fat reduction, compared with the usual products, is substantial (Wirth, 1988) Common salt (i.e. sodium) from the technological and microbial point of view could be reduced in meat products too, especially in liver and blood sausages and somewhat less in emulsion-type sausages and cooked ham. The microbial stability of low salt products could be compensated for by strict refrigeration. Critical from the microbiological point of view is a salt reduction in raw meat products, which are generally stored without refrigeration. Therefore, salt addition to fermented sausages should only slightly be lowered, and in raw hams any worthwhile salt reduction would involve too great a microbial risk (Wirth, 1989).

III. Microbial Stability of Low Fat and/or Low Salt Meat Products

The microbial stability and safety of most foods is based on combinations of preservative factors (hurdles), which the microorganisms present are unable to overcome. This is true for traditional foods with inherent hurdles as well as for novel products for which hurdles have been intelligently selected and are intentionally applied (Leistner, 1995). The most important hurdles in foods are temperature, water activity, acidity, redox potential, preservatives, and competitive microorganisms. However, more than 60 potential hurdles which influence the preservation and/or the quality of foods have been already identified, and the list of possible hurdles used in food preservation is by no means complete (Leistner, 1997). The replacement of fat as well as reduction or substitution of salt (sodium) might influence important preservative factors (hurdles) in foods and, thus, the microbial stability and safety of the products. The water activity (aw) hurdle is probably most affected, but the acidity (pH) as well as the effects of temperature and preservatives will also be influenced. Furthermore, the redox potential (Eh) and the microstructure of foods might be altered too. Thus, the mentioned hurdles need particular attention in modified meat products, and they will be discussed as follows:

A. Water Activity (aw)

The growth of microorganisms is much influenced by the water activity (ionic strength) of foods. Reduction of salt or replacement of fat in high moisture muscle foods will often result in an increase of water activity and thus diminish the microbial stability and safety of such products. Sodium chloride is of primary importance for lowering the aw of many muscle foods. If NaCI is replaced by other chloride salts (K, Ca, Mg) or polyphosphates then their contribution (particularly of KCI) to the ionic strength is quite similar to that of sodium chloride, and several commercial blends of potassium salts and polyphosphates are available as sodium chloride substitutes. On the other hand, sugars are much less effective with respect to the ionic strength, because about three times the quantity of sugars (sucrose, glucose, lactose), compared to sodium chloride, is needed to achieve the same aw-depression (Leistner et al., 1981). The effect of salt as well as sugar on the aw of meat products is obvious, since these solutes reduce the water activity by increasing the ionic strength in the fluid phase of the foods. In low salt emulsion-type sausage (13rnhwurst) compared with the normal products, the aw only increases slightly (i.e., from 0.980 to 0.985), but in low salt blood sausage (Kochwurst) the increase in aw is much more (from 0.970 to above 0.985). The latter is due to the possible larger reduction of sodium chloride in Kochwurst. High yield cooked hams (shoulder, loins) with technological feasible reduction of the salt content have a very high water activity close to 0.990, and thus need strict refrigeration (< 5°C). Fermented sausages during ripening should soon achieve an aw <0.95, in order to inhibit the growth of *Salmonella* spp.. However, if the salt addition is reduced from the normal 2.8% to 2.4% or even lower, then the products remain much longer above this critical aw-level, and thus are at risk related to *Salmonella* spp. and spoilage bacteria too (Wirth, 1989). For raw hams *Clostridium botulinum is* an hazard, and thus, these products must have an aw< 0.96 (corresponds to NaCl-content 4.5%), before they are further ripened at ambient temperatures (Leistner, 1990).

Fat influences the water activity of foods too, but only indirectly. If a food is composed of muscle (contains about 75% moisture) and fat (may contain only 5-15% moisture), then meat products high in muscle and low in fat will have a higher water content (and aw) than those composed of low muscle and high fat content. Also other dry ingredients (such as soy-protein or milk-powder) introduce little water into the food system and thus reduce the water activity. However, if fat replacers (e.g., starches, gums, alginates, pectins, inulin, hemicellulose, plant or animal proteins including surimi) bind water and increase the water holding capacity (WHC) they will increase the water content of the products, and thus their water activity. On the other hand certain fat replacers, like polydextrose, may act as humectants and reduce the aw of foods. Therefore, the effects of the many known fat replacers (until now more than 100) on the water activity of foods are quite complex. However, it is safe to assume that in most cases the reduction of the salt or the fat content of foods will increase their aw, and thus, will decrease the microbial stability and safety of foods, such as modified meat products.

B. Acidity (pH)

Some low salt meat products have a slightly higher pH compared with the normal products, and this is true for emulsion-type sausage (Bruhwurst) as well as for liver and blood sausage (Wirth, 1989). Therefore, these salt reduced meats are less stable with regard to their pH.This is of particular concern with liver and blood sausages, which have already even in the normal products relatively high pH values of about 6.3 and 7.2, whereas, normal Bruhwurst products have a pH of about 5.9 to 6.0.

If fat is replaced by proteins then the pH and/or the buffering capacity of heated meats might increase, and therefore, the microbial stability and safety of these products would decrease. The antimicrobial effects of weak organic acids is much influenced by the pH of the food, because the action results from the undissociated molecules rather than the anion, and they are more undissociated at lower pH. Thus, less preservation due to organic acids and their salts (e.g., acetate, sorbate) has to be expected in high pH values foods. On the other hand, in foods which undergo a desirable fermentation by bacteria (e.g., salami), a high buffering capacity of the food might delay somewhat the fermentation process. More important, in such foods the replacement of fat by fermentable carbohydrates (e.g., starches) will lead to a very strong and thus undesirable acidification of the product. Therefore, the pH and changes in the acidity during processing and storage of low fat muscle foods need particular attention.

C. Temperature (Heating and Chilling)

A diminished microbial stability and safety in low fat or low salt meat products require more careful chilling during storage of these products. In case of temperature abuse, e.g., during retail display or in the home of the consumer, however, such foods might become hazardous. Therefore, besides the temperature hurdle some additional hurdles should be incorporated into chilled products. This precaution is increasingly applied and sometimes called Invisible technology" (Leistner, 1995).

As far as the heat treatment is concerned, a higher water activity in low fat or low salt meat products might aid in the inactivation of microorganisms by heat. This could cause an increased stability, however, this effect in general should be only minor.

D. Preservatives (Additives)

Some additives (e.g., lactate, acetate or sorbate) might become essential for preservation if the water activity of meat products increases because of the substitutes for fat or salt. If low fat products contain more water due to the increased water holding capacity caused by fat replacers, then the water soluble preservatives (e.g., nitrite) might become diluted, and thus, are rendered less effective. In addition, nitrite is less effective at higher pH levels, and thus, the nitrite hurdle in modified meat products often will be diminished. This aspect should be taken into consideration. In general, the addition of preservatives should be calculated by taking the water phase of the food into account.

E. Redox Potential (Eh)

The influence of fat replacers and salt (sodium) substitutes on the redox potential of modified meat products has not been investigated. Proteinaceous fat replacers might increase the Eh-buffering capacity of a food, whereas, foods with a high water content should have a low Eh-capacity. The exclusion of oxygen (i.e., application of vacuum packaging or modified atmosphere) will have a synergistic effect on other hurdles in the food, especially with respect to aw and pH (Gould, 1995). Therefore, anaerobic conditions would foster the microbial stability and safety of modified meat products.

F. Microstructure (Microbial Stability)

The microstructure of some foods is significant for their microbial stability and safety. This is already well known for emulsions (e.g., mayonnaise) and fermented foods (e.g., salami). The microstructure of foods could change by the addition of some fat replacers, however, this effect has not yet been investigated, but should be kept in mind.

IV. Stability Management of Low Fat and/or Low Salt Meat Products

It has been pointed out in this contribution that in many instances low fat and/or low salt meat products will have a diminished microbial stability and safety, which might be compensated by improved refrigeration. However, it seems risky to rely solely on the refrigeration because temperature abuse could happen, and would be a constant threat. Therefore, the reduced microbial stability of such foods should be better defined and possibly compensated for by alternative hurdles, i.e., by intelligent application of hurdle technology. Since the knowledge in which respect the fat replacers and salt (sodium) substitutes will influence the microbial stability and safety of meat products is scarce and the effects are uncertain, important hurdles in modified products have to be measured and evaluated. Especially the water activity (aw) and the acidity (pH) in the final products before shipment and during storage are significant. The hurdle technology as a concept proved successful in the optimisation of traditional foods as well as in the development of novel products. However, hurdle technology should be combined, if possible, with HACCP and, if feasibel, with predictive microbiology. With this aim in mind, a „user guide" for product development has been suggested which comprises all three concepts (Leistner, 1994). This user guide certainly could be applicable for optimization of the microbial stability and sensory quality of low fat and/or low salt meat products too.

V. Summary

In the design and production of low fat and/or low salt meat products the nutritional aspects have been much more emphasized than the microbial aspects. However, since such foods have often a diminished microbial stability and safety the latter should not be neglected, because these foods will only be continously accepted by the consumer if they cause no food-poisoning and do not spoil easily. Of major importance for the microbial stability of low fat and/or low salt meat products is probably the increased water activity (aw) of modified products. However, the acidity (pH) might be unfavorable too, added preservatives might be diluted and thus rendered less effective. Furthermore, the redox potential (Eh) and the microstructure might change in modified meat products, even these aspects have not yet been investigated. To keep low fat and/or salt muscle foods microbiologically stable and safe, the refrigeration during storage of these products must be perfect. Since this cannot be always guaranteed, the weak hurdles in modified meat products should be compensated for by alternative preservative factors, i.e., by applying the concept of hurdle technology. In the design and processing of low fat and/or low salt meat products the microbiologists should take an active part, and the close co-operation with technologists will prove fruitful. Quantititive data on the impact of the different replacers for fat and the substitutes for salt (sodium), as well as relevant combinations, on the important preservative factors (hurdles) of modified meat products are needed. In the design of such food products intentional hurdle technology, including predictive microbiology, should by applied, and the process should be controlled by HACCP.

VI. References

The present contribution is a summary of a chapter on „Microbial Stability and Safety of Healthy Meat, Poultry and Fish Products" of the forthcoming book „Healthy Production and Processing of Meat, Poultry and Fish Products", edited by A.M. Pearson and T.R. Dutson, which will be published soon by CHAPMAN & HALL. The cited references are included in my chapter, and comprehensive information on the subject contains the book.