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The role of meat-borne strains of *Lactobacillus* in raw sausage fermentation

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Fermented sausages are defined as ground meat mixed with salt and curing agents, stuffed into casings and subjected to a fermentation process in which lactic acid bacteria play a crucial role. Most fermented sausages are shelf stable without cooling and are commonly consumed without application of any heating process. They are spreadable or become sliceable during ripening process which involves fermentation and reduction of the water content by drying. There are many factors affecting the quality of fermented sausages and each of these factors has an influence on the fermentative transformation of the raw materials into the desired end product during the ripening process. The aims of this process are the following: reddening, acquisition of flavor, sliceability, and resistance to spoilage.

Lactic acid bacteria would contribute to all aims of the ripening process. The lactic acid produced during the fermentation process, from sugars added to the sausage mixture, lowers the pH, imparts a tangy flavor to the product, and denatures the meat protein. This denaturation, which also results in water release, is largely responsible for the texture associated with fermented sausages. Moreover, the low pH attained inhibits the development of contaminating microflora and improves hygienic stability of products.

The reddening is as a result of an acid catalysed disproportioning of nitrite according to the aquation $3HNO_2 \rightleftharpoons 2NO + HNO_3 + H_2O$. Nitrogen monoxide reacts subsequently with myoglobin to finally from the cured meat colour nitrosomyoglobin.

The dominating lactic acid bacteria in both the commercial products and in ripening sausages were atypical streptobacteria. They are generally psychotrophic and differ from the more known lactobacilli that are also associated with fermenting meat by their low pH tolerance (pH limit 3.9-4.1). The majority of the atypical streptobacteria can be allotted to *L. sake* and *L. curvatus*. These two species have in common that they constitute the characteristic microflora governing the microbial process in uncontrolled meat fermentations. They are highly competitive and well adapted to this environment. Some strains of meat-borne lactobacilli exhibit the essential activities like nitrate reductase, nitrite reductase, catalase, lipase and protease, respectively.

For both catalase and nitrite reductase activities were found that they are either heme-dependent or -independent. Since meat contains sufficient heme, there should be no limitation for heme-dependent activities in fermenting sausages. It is characteristic for all strains of *L. curvatus* that they are devoid of catalase activity whereas this activity is present in *L. sake*.

A corresponding heme-dependent activity was also described for the nitrite reductase activity in strains of *L. plantarum*. On the other hand, a heme-independent nitrite reductase is present in *L. sake*.

For development of flavor, the activities of protease and lipase are essential and prerequisite. Lipolysis is generally considered to play a key role in the development of aroma during fermentation of sausages. The strains of *L. sake* and *L. curvatus* exhibit lipolytic activity *in vitro* whereas pediococci and typical streptobacteria are devoid of that property. *In vitro* studies have shown that proteolytic activity can be found in strains of both typical and atypical strepbacteria. The major protease activity is, however, derived from the endogenous enzymes of the meat. It has not yet been studied about lipolysis and proteolysis by the lactobacilli during fermentation.

Meat-borne strains of *Lactobacillus* have been investigated for their potential to produce antagonistic compounds. This property has been detected in strains of *L. curvatus, L. plantarum*, and *L. sake*.

It was observed that strains of *L. curvatus* and *L. sake* inhibit not only food-poisoning bacteria but also strains which are commonly incorporated into multiple-strain starter preparations. Thus, the knowledge of these properties provides a means of selecting the optimum combinations of starter strains that reduce potential hygienic risks in fermenting meat products. This knowledge is also important to avoid a combination of those strains of *L. sake* which exhibited a strong antagonism against *M. varians*. In fact, it has observed that nitrate reduction and the reddening reaction were suppressed in sausages, when such a combination was used. The application of the *L. sake* strains reduced strongly the numbers of *S. aureus* in both spreadable and sliceable sausages.

It is not yet sufficiently known which physiological properties of the lactic acid bacteria can be usefully employed to simplify the microbiology of the fermentation process and to obtain the optimum quality of sausages. Besides a high competitiveness of the starter strains and a safe decrease in pH, activities that improve flavor, colour, and hygienic safety should be targets of future search for new strains of lactic acid bacteria.