Bacterial Starter Cultures in Sausage Products

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For centuries, fermented sausage has been produced, initially as a means of preservation and more recently for the particular flavor effects achieved, without real knowledge of or any rational effort to control the microbiology involved. Only within the last 20 yr has this situation changed, and today many producers of semi-dry sausage use either a lyophilized or frozen concentrate starter culture of *Pediococcus acidilactici*, originally described as *P. cerevisiae*, to achieve a much greater degree of uniformity of flavor, appearance and texture in approximately one tenth the time required for the traditional process. Starter cultures for fully dry sausage are under development and should achieve commercial status within a relatively short time. Novel meat and simulated meat products may be anticipated as a result of the use of the starter culture technique.

Traditionally, fermented sausage, known as dry sausage or semi-dry sausage, became an accepted food because it offered variation in the diet during the warm months when lack of refrigeration or other means of preservation severely limited the meat items which could be consumed with any degree of safety. By using the proper techniques, sausage could be prepared during the winter when game or domestic animals could be slaughtered and consumed during the following summer. The derivation of the names dry, semi-dry, and summer sausage is fairly obvious; these sausages do dehydrate to varying degrees depending upon the length and conditions of storage, and they could be consumed in the summer in contrast with fresh sausage, which could only be eaten in the cooler parts of the year.

There were, of course, wide variations in the flavor of the sausage produced by this crude means and, in time, certain localities became known for the particular flavor of the local product, *e.g.*, Genoa salami, Thuringer sausage, and Lebanon bologna. There is good evidence that the particular flavors of Westphalian, Virginia, and Kentucky hams are due, at least in part, to microbial action as well.

After centuries of fermented sausage production strictly as the Wurstmacher's art, the realization that microorganisms were responsible for the flavor and preservation of this type of product came about comparatively recently, and a patent covering the use of a bacterial starter culture in sausage was issued in 1940 (Jensen and Paddock, 1940). A commercial starter culture was developed (Deibel and Niven, 1957) and offered to the meat industry in this country in 1957 (Harris *et al.*, 1957; Niven *et al.*, 1959). Prior to that time, fermented sausage had been made by the traditional process.

TRADITIONAL PROCESS

The traditional process for fermented sausage consists of grinding or chopping the meats, mixing in sodium chloride and either sodium or potassium nitrate, mixing in spices or other seasonings, and transferring the mixture to curing pans. The meat mixture is tightly packed in layers about 6 to 8 in. deep and held at 40° F for 48 to 72 hr. During this curing period, nitrate-reducing bacteria convert some of the nitrate present to nitrite, which enters into the curing reaction with the meat pigments to produce the typical red cured meat pigment. Following the "pan-cure," the sausage mixture is removed from the pans, remixed, and stuffed into casings typical of the particular sausage. The sausage, typically, will be held in a "green" room or drying room at 50° to 60° F (10° to 15° C) for 12 to 48 hr. During this time the curing process is completed and some drying or firming takes place. Following this period, the sausage will be removed to the smokehouse, if it is a smoked variety, and the length of the smoking process and the temperature cycle will vary depending upon the variety of sausage and the degree of tangy flavor desired (American Meat Institute Foundation, 1960). A typical dry sausage will be moved from the green room to the drying room and held for periods up to 90 days to achieve the flavor and firm texture expected in these types of sausages.

The traditional process is, of course, an extremely long process, requiring not only an excessive amount of handling and labor, but a very appreciable investment in inventories and extensive drying room areas. Dependent as it is upon chance or random contamination with wild organisms, the results achieved with the traditional process vary all the way from Epicurean on one hand to inedible on the other. If the right organisms are present to the practical exclusion of the wrong ones, the flavor, color, texture and aroma of the fermented sausage will be ideal. If, however, the wrong organisms gain control, the sausage may be completely unappetizing and inedible, or may actually explode in the process. In between these extremes, we see the results of mixtures of good and bad contaminations, where the final product is judged to be just barely or very nearly acceptable.

Early attempts to maintain desirable fermentations paralleled those in other areas of fermentation; soap and other sanitizers were used sparingly at best in the curing pans, and a portion of each batch might be held over to "start" the next batch. This latter practice, which earned the inelegant name "back slopping," leaves a lot to be desired. Aside from the thought that, theoretically at least, a small amount of the meat from the very first batch is present in each production lot, the subsequent batch will normally be well under way before even a preliminary judgment can be made of the quality of the batch from which the "seed" or "back slop" was saved. In brief, this is as excellent a way to promote the undesirable as well as the desirable organisms.

STARTER CULTURE PROCESS

The starter culture which was first offered to the sausage processors in 1957 consists of lyophilized cells of *Pediococcus acidilactici* on a dextrose carrier. Initially, this culture was

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designated as *P. cerevisiae*, but subsequent refinements in classification techniques indicate the *P. acidilactici* to be the correct nomenclature. This organism does not reduce nitrate to nitrite and, to permit the elimination of the pan-curing step, along with the introduction of the culture, a change from a straight nitrate cure to a straight nitrite or a mixed nitrate-nitrite cure was made. In the meat mixture, *P. acidilactici* requires only the addition of dextrose for optimum growth and the use of dextrose is well covered in the instructions for using or evaluating the starter culture.

The process for making fermented sausage using the culture consists of grinding or chopping the meats, mixing in sodium chloride, sodium or potassium nitrite, spices and other seasonings, dextrose and, finally after all other ingredients are thoroughly distributed, the starter culture suspended in water. The mixture is immediately stuffed into appropriate casings and moved to a warm, humid area (80° F, 85% to 90% relative humidity) for 12 to 16 hr to permit the organisms to rehydrate and return to the vegetative state. The sausage is then moved to the smokehouse and held at 100 to 110° F, 90% relative humidity, until the desired acid production is achieved. This will usually require from 15 to 20 hr, depending upon the variety of sausage and the personal preferences involved. At this point, the sausage may be heated to a higher temperature, 137° F is typical, again depending upon the variety of sausage, and then moved to a holding cooler. Smoke may be applied during any portion of the time in the smokehouse.

The flavor of sausage sampled soon after removal from the smokehouse is variably described as "harsh, chemical, sharp, unpleasant," and the initial evaluation could well be that the culture is worse than useless. However, after 2 to 3 days in the cooler, the flavor will now be found to be the typical, tangy flavor of this type of sausage. In addition to reducing the production time from around 150 hr for thuringer, cervelat, or summer sausage to somewhere in the area of 32 to 40 hr, the use of the starter culture will insure that the final pH and flavor will show only small variations from batch to batch. By eliminating dependence on chance contamination and greatly reducing the time during which wild organisms can grow and influence the results, much of the source of variation in the flavor has been either eliminated or reduced.

P. acidilactici was selected from the 32 strains of lactobacilli and nine strains of pediococci isolated from fermented sausage (Deibel *et al.*, 1961) as having the desired physiological characteristics and also being capable of surviving lyophilization and rehydration. The lyophilization technique was selected as the method of choice to place a viable culture in the hands of sausage manufacturers all over the country in a reliable and relatively inexpensive form, and the organism of choice necessarily had to survive this treatment (Deibel and Niven, 1957).

In 1960, the Institute of Food Technologists awarded its Industrial Achievement Award jointly to the American Meat Institute Foundation and Merck & Co., Inc., for the development and commercialization of this starter culture. During the 12 yr the lyophilized culture has been available, it has been well received and, in 1968, was used in approximately 20 million lb of semi-dry sausage.

In 1965, the use of the lyophilized culture was reevaluated and the weak spot was found to be the rehydration period. Many plants did not have completely satisfactory facilities for this stage of production and, as a result, times, temperatures and humidities tended to change with the production schedules, seasons of the year, or even time of day. During this period, the pediococcus is not actively growing and yet conditions are ideal for wild contaminants to multiply and influence the ultimate results. Elimination of the necessity for rehydration would reduce the largest source of variation, as well as further reduce production times. With the realization that the technology of storing, handling and shipping frozen material at low temperatures had developed to a considerable extent, a frozen concentrate of *P. acidilactici* was developed.

FROZEN STARTER CULTURE

In 1968, a frozen starter culture was offered to the trade and has found very rapid acceptance. The process of making fermented sausage with this culture consists of grinding or chopping the meat, mixing in salt, nitrite, seasonings, dextrose, and finally, the culture, which has been thawed and suspended in water. The sausage is stuffed into suitable casings, moved directly to the smokehouse, and brought to 100° to 110° F as rapidly as possible. When the degree of acidity desired has been reached, requiring 10 to 15 hr depending upon the variety, the sausage is finished off as before and moved to the cooler. The uniformity of color, flavor, texture and pH has been extremely good (Everson *et al.*, 1970).

One of the more novel aspects of the frozen culture has been the packaging used. Since it is necessary to measure rather small increments of the culture, the culture is packaged in 4-oz and 6-oz cans before freezing. The 4-oz can is designed for a 200-lb batch or multiple, while the 6-oz can serves for 300 lb or multiples. The cans are packed in cases of 24 cans for ease of handling in storage and shipping, and have proven easy to handle in the sausage operation.

Successful development of the frozen starter culture of *P. acidilactici* earned a Putnam Food Award for 1969, given jointly to Merck & Co., Inc. and Microlife Technics.

CONCLUSIONS

The introduction of the lyophilized culture and the frozen culture of *P. acidilactici* has reduced the production time for a typical semi-dry sausage from 150 hr to 40 hr to 20 hr. Uniformity of the color, texture, flavor, pH, and aroma has been improved to the point that batch to batch variations are extremely small when materials and process conditions are controlled carefully. In 1969, the two cultures will be used to produce approximately 30 million lb of semi-dry sausage and their usage is expanding. This production time required, particularly with the frozen culture, makes possible the scheduling and production of fermented sausage in the modern facility without disrupting the production of other types of sausage.

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