Meat fermentation history and processes

The use of salt as a method of food preservation is a process that has been used well before the Christian era in well-developed societies, such as ancient Egypt and China. This knowledge quickly spread from the south to the north in Europe. Due to its long and difficult transportation, salt was expensive and scarce, especially in remote inland areas (Skara et al. 18). Instead of using full- salt preservation method, they began to experiment using lower salt concentration when preparing and storing caught fish and other meat products. They found this method of preservation successful and produced edible, tasteful and a longer lasting product. This method was varied depending on the salt concentration, storage temperature, container, and handling. The preservative effect of salt is because of the osmotic pressure that it creates via absorption. Its activity is much like that of a red blood cell. If you take a red blood cell and place it in water, because of its osmotic pressure and thin semi-permeable membrane, the cell, with its somewhat salty interior next to the water, will absorb more and more water until it explodes. In the reverse effect, if the cell is placed in a water that is saltier than the than the cell, the cell will gradually loose water and shrink. This is the same thing that happens with most molds and microbes. Because of its ability to raise the osmotic pressure, things that may otherwise spoil meat will have trouble surviving and reproducing when the moisture is sucked from them. The more salt that is added to the meat the longer the preservation effect will last. Much like adding salt to foods, fermentation is another mean of meat preservation.

Fermentation is the process in which carbohydrates are converted into acids or alcohols. This process takes place in microorganisms like bacteria and fungi. Yeast, a form of fungus, converts sugars into alcohol in order to obtain energy. The bacteria converts the sugars into lactic acids to obtain energy. There are two types of fermentation, ethanol and lactic acid fermentation. Ethanol fermentation occurs when yeast and some types of bacteria converts glucose into two molecules of pyruvate. The pyruvate is then converted to acetaldehyde and in turn carbon dioxide is released during this reaction. The acetaldehyde is then converted into ethanol. In lactic acid fermentation the bacteria, which can also be found in the skeletal muscles of animals during low oxygen levels, like with ethanol fermentation, glucose is converted into two molecules of pyruvate. The enzyme lactate dehydrogenase converts the pyruvate into lactate. (Bai et al. 89)

The fermentation process unlocks a wide variety of flavors and foods that otherwise seems bland or unpalatable become tangy, salty, sour, or even sweet. The human gut is home to a wide variety of probiotics. These probiotics are good bacteria that helps to maintain digestive and immune systems. By preventing the growth and spread of harmful bacteria, probiotics also aid in the prevention of illnesses. Along with having a variation in fermentation mechanisms there are also a variety of ferments. Because many traditional ferments are difficult to categorize they are not controlled and have many fermentation processes working in unison. The most common types of ferments are bacterial, mold, and yeast ferments.

Bacterial ferments are the most common types that is driven by various strains of beneficial bacteria. In most common bacterial ferments the requirements that is needed to ferment the foods is naturally occurring and already present in the foods. Mold ferments, the rarest form of fermentation, plays an interesting role in fermentation, it produces unique flavors, and a variations of molds are used. Bacterial and yeast ferments, another common type, requires bacteria and yeast working in unison. Some unique ferments require starter cultures, most of which can be maintained and shared. To further facilitate fermentation, yeast can be added to foods. The yeast eats the naturally occurring sugars, carbohydrates, in foods the resulting product is alcohols which is the foundation for fermented beverages.

There are three way to inoculate meats to start the fermentation process. The first is through natural inoculation or spontaneous fermentation, where the bacteria and molds that are naturally present in the meat, air, and environment are utilized. This is a highly variable process and is rarely used because the process changes depending on the local environment, which constitutes a part of the ' house flora' (Leroy et al. 270). This process is still used by some small manufacturers. The process known as batch inoculation or back slopping utilizes leftover meat from one batch to inoculate another. This method offers the greatest risk of microbial contamination, even though it is still used by some small artisans. The third process is the use of a starter culture, this method is the most widely used inoculation techniques which is predominantly used by large scale commercial producers. This method provides the safest and most convenient way to inoculate a large number of meats with the correct microbes.

A meat starter culture is a viable microorganism that is added directly to meats to improve its quality, safety, and to enhance consumer reliability of the meat product. The nutritional quality of the meat should be maintained or improved. A starter culture should exhibit four main qualities. It should be salt and nitrate- tolerant, grow at a temperature range of 27 to 43 degrees Celsius, produce compounds that result in pleasant odors, and it must not be harmful to human health (Smith and Palumbo 997). The use of starter cultures in meat fermentation provides a number of beneficial results. One being that the processing time is reduced because there is no need to select and grow the desired microbial species by time consuming salted meats or ' back sloping'. Another benefit to using starter cultures is that it decreases the handling of raw meats. Because of their consistency, batch to batch variation is decreased, resulting in a more consistent acid product, which produces a product that is more consistent in flavor and overall desirability (Smith and Palumbo 997). A major advantage to the accelerated acid production by starter cultures is the inhibition of foodborne pathogens and microbial toxin production as well as spoilage.

The addition of favorable microorganisms to meats have four different purposes, mainly to improve safety by inactivating pathogens. The second is to improve the overall stability, by extending the shelf life and inhibiting undesirable changes by spoilage microorganisms or abiotic reactions. The third is to provide diversity by modifying raw material to gain new sensory properties, and provide health benefits (Lucke 105). Over the past couple decades, meat fermentation has developed into a science. Fermentation can now be described as a low energy biological acidulation preservation method. The resulting product, is a unique and distinctive meat properties, like flavor palatability, color, and tenderness. These changes are stimulated by the biological systems of microorganisms that are in the meat product. These products grow and produce cultures that are manipulative and drive metabolic changes within the meat. When considering fermented meats, the most common type is sausage. There are four main microorganism that are involved in sausage fermentation, lactic acid bacteria (LAB), gram-positive catalase-positive cocci (GCC), molds, and yeasts (Leroy et al. 270).

Lactic acid bacteria dominates the microflora through the production of lactic acid, acetic acid and bacteriocin. The bacteriocin creates pores in the cytoplasmic membrane of the susceptible cell of the secondary product, they have a toxic effect on the *Clostridium* pathogenic bacterium that are gram positive (Hammes 151)Meat fermentation, a traditional European practice, involves major LAB species. Due to its ability to produce bacteriocin certain LAB are used as a biopreservative cultures on meat products. As a starter for meat fermentation LAB is needed to tolerate the levels of salt and nitrite added to the product. Because of the lack of sterilization in the manufacturing process, the release of lactic acid combined with the decrease in pH prevents contamination of harmful microorganism. (Takeda et al. 507). The antioxidant activity that is present in meat products also inhibit color deterioration, microbial growth, and lipid oxidation. The drop in pH by lactic acid and acetic acid inhibits the growth of *Listeria* , *Salmonella* and *E. coli* . *Salmonella* e are most often found if foods of animal origin and foods that have been handled or contaminated by man.

As the lactobacillus that is produced, consumes the dextrose they produce a lactic acid that lowers the pH of the product. The lowering of the pH acts as a preservative that helps to denature the protein, giving the meat its characteristic texture. The United States Department of Agriculture (USDA) has developed criteria to make the fermentation process safe. They require the sausage to be stable meaning it must have a pH less than 5. 0, a water activity of less than . 87, and the protein to fat ratio must be at least 3: 1: 1 ratio (Incze s169). As the rate at which pH drops it helps to determine the flavor of the sausage. A fast drop in pH creates a tangy summer style sausage, while a slow and more controlled drop creates a milder salami style sausage. To help determine the moisture content some add *Penicillin* mold to the outside of the sausage, this mold draws out the water from the sausage which helps to lower the water activity and promote the case hardening.

A variety of compounds contribute to the desired taste and aroma of fermented sausages. Some are added to the product like salt, spices, or smoke, while other are formed by abiotic reactions, tissue or microbial enzyme during ripening (Lucke 105). The resulting product of carbohydrate fermentation by LAB, gives the sausage and acidic flavor. The intensity of this flavor is dependent on the pH value. GCC microorganisms affects the aroma and the taste of the fermented sausage by transforming compounds that originates from lipids and proteins resulting in compounds that are degraded and adds to the desired aroma of sausages. (Lucke 105)

Fermentation by fungi is one of the oldest forms of food processing and fermentation. Some of its positive aspects includes, characteristic flavor and aroma, the formation of a typical whitish appearance, and the added protection of the sausage form spoilage by other molds or bacteria. Suitable surface starter colonizes rapidly and adheres to the sausage surface, which enable it to suppress undesired molds and protect from the detrimental effects of oxygen. There are also undesirable effects in meat fermentation that are associated with the growth of fungi, which leads to spoilage and possible production of mycotoxins. To prevent unwanted fungal contamination, various sausage producers use starter cultures of *Penicillium nalgiovense* and the lesser extent *Penicillium chrysogenum,* in their fermentation (Giancarlo et al. 91). These strains have not been known produce any of the known toxic secondary metabolites. These fungi coat the sausage casing, in hopes of improving and standardizing the quality of sausage. To ensure the safety of the final product strains are carefully selected and used during the fermentation process.

LAB, in meat fermentation serves three of the four main purposes of the addition of microorganisms. The three being to improve safety, improve stability, and to extend the shelf life of the meat. Whereas other microorganism, mainly those that are catalase-positive cocci (*Staphylococcus, Kocuria*), yeast (*Debaryomyces*) and molds (*Penicillium*), provide stability and diverse sensory effect (Lucke 105). If lactic acid is used as a starter culture, it must be homofermentative. Gas production and fermentation products, resulting from anything but lactic acid, might contribute to defects such as off- flavors (Smith and Palumbo. 997). The inoculation of meats with lactic acid bacteria is to not only produce lactic acid quickly but to also form reliable sugars, usually glucose. Due to their fastidious activity LAB require preformed amino acids, Vitamin B, purine and pyrimidine bases for growth. With respect in particularly vitamins and amino acid content, the nutritive value of the meat may be decreased by fermentation. In contrast because its preservative effect, fermentation contributes to nutrition because the product is available longer than fresh and cooked meats that might have otherwise spoiled.

The use of nitrate and or nitrite offers a unique characteristic of meat fermentation. These agents play a role in obtaining specific sensory properties, stability and hygienic safety of products such as fermented sausages and ham (Hugas and Monfort 547). The use of nitrate is a traditional method in the curing process and it requires the reduction to reactive nitrite. There are two types of curing, wet and dry. Wet curing takes place when the meat is placed in a brim or mixed into minced meats and takes one to two days. Dry curing takes several weeks and the meat is covered in a curing mixture and salts slowly diffuse into the meat. During the fermentation process nitrates are converted into nitrites by endogenous microorganisms. This process takes several days and the resulting nitrites reacts with water to form nitric oxide. The nitric oxide reacts with myoglobin to form nitrite myoglobin, which helps to preserve the color of the product(Hugas and Monfort 547). The accumulation of lactic acid, formic acid, ethanol, ammonium, fatty acids, hydrogen peroxide, acetaldehyde, antibiotics and bacteriocin, aid in the inhibition of pathogenic and spoilage bacteria. The resulting nitrites also aid in the prevention of botulism and listeria.

The use of selected psychotropic LAB may reduce the risk of salmonella and other vegetative pathogens during fermentation, and may contribute to the inhibition of *Listeria monocytogenes* on some perishable meat products. The most important mode of action of a protective culture is the formation of lactic acid. As a result of the formation of lactic acid, the effect of bacteriocin is reduced by their inactivation and a possibility of resistance development. The addition of protective cultures are only beneficial to the meat if they do not destroy organism that would otherwise suppress pathogens. Because of their somewhat limiting effect, the use of protective cultures cannot compensate for poor manufacturing processes. Starter cultures may affect the taste and aroma of fermented sausages, which may a result of the microbial transformation of compounds that is generated by the meat enzymes and abiotic reactions.

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