Chapter 3

The Magic Behind Fermented Sausages - *It's All About Bacteria*

3.1 Understanding Bacteria

Making fermented sausages is a combination of the art of the sausage maker and unseen magic performed by bacteria. The friendly bacteria are working together with a sausage maker, but the dangerous ones are trying to wreak havoc. Using his knowledge, the sausage maker monitors temperature and humidity, which allows him to control reactions that take place inside the sausage. This game is played for quite a while, and at the end a high quality product is created.

This is basically how they have been made for centuries but recently we have come to understand the inner Whys and Hows of the fermentation process. Let us quote an old military motto: *"You have to know your enemy if you want to win the battle"* holds true for making fermenting sausages and only by understanding bacteria behavior we can fight or control them.

We have to create conditions that will:

- Inhibit spoilage and dangerous bacteria.
- Take a good care of friendly bacteria so they can prosper and work for us.

The start of fermentation is nothing else but a war declaration by all bacteria residing inside the meat, and the stuffed sausage becomes the battlefront. We have to protect the product at all costs and the two best weapons we have at our disposal are increasing meat acidity (lowering pH) and lowering its water content (Aw).

3.2 Microorganisms

All microorganisms can be divided into the following classes:

- Bacteria
- Yeasts
- Molds

They all share one thing in common: they want to live and given the proper conditions they will start multiplying. They don't grow bigger, they just divide and divide and divide until there is nothing for them to eat, or until conditions become so unfavorable that they stop multiplying and die.

All bacteria need moisture, nutrients, and warm temperatures to grow. Most of them love temperatures that revolve around the temperature of our body (36.6º C, 98.6º F). Holding products at higher temperatures (greater than 130º F, 54º C) restricts the growth of bacteria. Increasing temperature over 60º C (140º F) will start killing them. The USDA recommended safe temperature for cooking meats is 160º F (72º C).

Most bacteria need oxygen (aerobic), others thrive without it (anaerobic). All of them hate cold, and around 32º F, (0º C) they become lethargic, and will become dormant when the temperature drops lower. Keeping them at low temperatures does not kill them, but only stops them from multiplying. Once when the conditions are favorable again, they will awaken and start growing again. Some bacteria tolerate the presence of salt better than others and we take advantage of this when curing meats.

Other bacteria (e.g. *Clostridium botulinum*) are able to survive high temperatures because they form spores. Spores are special cells that envelop themselves in a protective shell (cocoon) and become resistant to harsh environmental conditions. Once conditions become favorable, the cells return to the actively growing state.

Meat contains about 75% of water and this moisture is the main reason that it spoils. It is a community pool and if the weather is warm, all bacteria types go swimming. They are having a lot of fun but what's worse, given favorable conditions they can double up in numbers every 20 minutes. In a refrigerator their number will also grow, albeit at a reduced pace, but they can double up in 12 hours. Short of deep freezing, it is impossible to stop bacteria from contaminating meat, but we can create conditions that will slow down their growing rate. At room temperatures bacteria will grow anywhere they have access to nutrients and water.

3.3 Restricting Bacteria Growth

Bacteria are walking their way into the meat from the outside. Most of them need oxygen to survive and there is a lot of air between particles of minced meat. Meat which is finely comminuted is at higher risk due to its large surface area, and this is why ground meat has the shortest life.We all know that meat left at room temperature will spoil in time and that is why it is kept in a refrigerator/freezer. Yet dry fermented or air dried sausages are made of raw meat and not cooked, and don't have to be stored under refrigeration. What makes them safe?

Bacteria growth can be restricted by:

- Temperature
- Time
- Acidity
- Moisture
- Salt

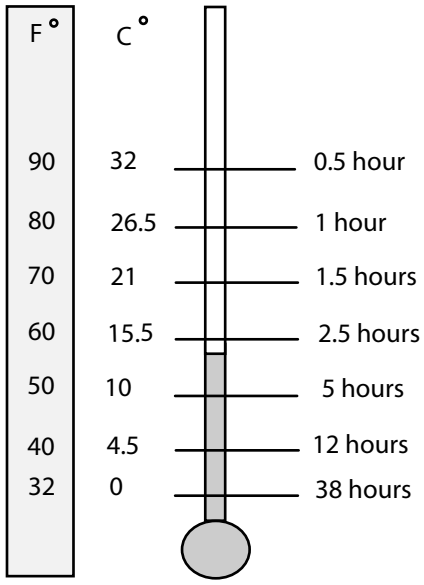
The table on the right shows how fast bacteria can grow at optimal conditions. *Temperature and time are the factors that affect bacterial growth most.* Below 45° F bacteria grow slowly and at temperatures above 140° F they start to die. In the so called "danger zone" between 40-140° F many bacteria are growing very well. For instance, the infamous *E.coli* grows best at 37° C (98° F) and *Staph.aureus* at 30°-37° C (86°-98° F).

When bacteria grow, they divide and increase in numbers, not in size. Looking at the table it becomes very clear what happens to a piece of meat left on the kitchen table on a beautiful and hot summer day.

Bacteria Growth in Time

Number of bacteria	Elapsed time
10	0
20	20 minutes
40	40 minutes
80	1 hour
160	1 hour 20 min
320	1 hour 40 min
640	2 hours
1280	2 hours 20 min
2560	2 hours 40 min
5120	3 hours
10,240	3 hours 20 min
20,480	3 hours 40 min
40,960	4 hours
81,920	4 hours 20 min
163.840	4 hours 40 min
327,680	5 hours
655,360	5 hours 20 min
1,310,720	5 hours 40 min
2,621,440	6 hours

3.4 Bacteria Growth With Temperature



It can be seen on the left that at 32° F (0° C) bacteria needs as much as 38 hours to divide in two. That also means that if our piece of meat had a certain amount of bacteria on its surface, after 38 hours of lying in a refrigerator the amount of bacteria will double. If we move this meat from the refrigerator to a room having a temperature of 80° F (26.5° C), the bacteria will divide every hour (12 times faster). At 90° F they will be dividing every 30 minutes.

Fig. 3.1 Bacteria growth with temperature.

The above thermometer drawing has been compiled from the data we found at the College of Agriculture, Auburn University, Alabama. It shows the time that is required for one bacteria cell to become two at different storage temperatures. Looking at the above drawing we can see that once the temperature reaches 50° F (10° C), bacteria will double up twice as fast every time we raise the temperature by about 5° F. From the above examples we can draw a logical conclusion, that if we want to process meats *we should perform these tasks at temperatures not higher than 50° F (10° C)*. And those are the temperatures present in meat processing plants. You might say that lowering the temperature of the room will be better still. Of course it will be better, but people working in such conditions for 8 hours a day will find it very uncomfortable. Keep in mind that meat is processed at 50° F (10° C) just for a short while and then it goes back into a cooler. Bacteria growth data in the above tables hold true for optimal conditions: no salt or nitrite and ample supply of moisture. Once we introduce conditions that are unfavorable to bacteria (salt, nitrite, low pH, little moisture), their growth will be inhibited.

Acidity - Fermentation restricts the growth of bacteria by increasing the acidity (lowering the pH) of the product. Generally a pH of less than 5.0 will severely restrict or completely stop the growth of harmful bacteria.

Salt and Moisture. Salt and moisture content in a product can be effective in controlling the growth of harmful bacteria, but some organisms (e.g. *Staphylococcus aureus*) can survive high salt and low moisture levels. Bacteria which are of concern to us when making meat products can be classified as:

- Food spoilage bacteria.
- Dangerous (pathogenic) bacteria.
- Beneficial bacteria.

3.5 Food Spoilage Bacteria

Spoilage bacteria break down meat proteins and fats causing food to deteriorate and develop unpleasant odors, tastes, and textures. Fruits and vegetables get mushy or slimy and meat develops a bad odor. Most people would not eat spoiled food. However, if they did, they probably would not get seriously sick. Bacteria such as *Pseudomonas spp*. or *Brochotrix thermosphacta* cause slime, discoloration and odors but don't produce toxins. There are different spoilage bacteria and each reproduces at specific temperatures. Some can grow at the low temperatures in the refrigerator or freezer. Others grow well at room temperature and in the "Danger Zone" (40-140° C, 4-60° C). Under the correct conditions, spoilage bacteria reproduce rapidly and their populations can grow very large. Spoilage bacteria love moisture and stop growing at Aw < 0.97.

3.6 Pathogenic Bacteria

It is commonly believed that the presence of bacteria creates immense danger to us but this belief is far from the truth. The fact is, that a very small percentage of bacteria can place us in any danger, and most of us with a healthy immune system are able to fight them off. *Pathogenic bacteria cause illness.* They grow rapidly in the "Danger Zone" – the temperatures between 40 and 140° F – and *do not generally affect the taste, smell, or appearance of food.* Food that is left too long at warm temperatures could be dangerous to eat, but smell and look just fine. *Cl.botulinum*, *Bacillus cereus* or *Staphylococcus aureus* infect food with toxin which will bring harm to us in just a few hours. Still others, like *Salmonella* or *Escherichia coli* will find the way with infected meat into our intestines, and if present in sufficient numbers, will pose a serious danger. Pathogenic bacteria hate cold conditions and lie dormant at low temperatures waiting for an opportunity to jump into action when the conditions get warmer again.