Three Critical Steps for Making Quality Processed Meats at the Lowest Cost

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SUMMARY

Meat is a complex raw material. Processed meats combine this complex material with ingredients to form even more complex mixtures. The physics associated with making processed meat are equally complex. Understanding the basic physics associated with the critical processing steps will help deliver the best possible quality while maximizing yield and allowing least cost formulation.

Meat science traditionally focuses on the meat and the interaction between the meat and various ingredients. However, the physical phenomena which occur during processing interact strongly with the meat and ingredient systems to create the desired product attributes and are a significant factor in the cost of production.

While one can fairly argue that all steps in the manufacturing of processed meats are important, three process steps consistently stand out as critical: mixing, stuffing and chilling. These three steps not only impact everything downstream but problems created in these steps cannot be undone later in the process.

MIXING

Mixing processes in many industries have the sole purpose of creating homogeneous blends of different materials. Mixing in the meat industry is much more complicated. If the mix process is not designed properly, some ability of the protein to bind fat and water may be left untapped or the ability of the protein to bind fat and water can be damaged. These cannot be recovered in later processing steps.

Production of processed meat products requires the combination of one or more cuts of meat with water, salts and other ingredients. Simply combining ingredients with meat protein allows the protein to bind fat and water more effectively. However, the input of mechanical energy into this system profoundly changes the way that salts, water, fat and protein interact with one another.

Superficially, the input of mechanical energy allows more thorough contact between the meat and the other ingredients. However, the impact goes much deeper than enhanced dispersion. Chemical and structural changes occur at the microscopic level which free up protein for fat and water binding. The microscopic scale at which these changes occur is much too small to be attributed solely to the bulk material movement imparted by the mixer. It is the combination of ingredients and mechanical forces that produces stable meat batter capable of binding fat and water.

The manner in which mechanical energy is delivered to the mixture has a significant impact on the result. Key factors in delivery of mechanical energy include mixer design, mixer size, vacuum level, mixer shaft speed and mixing time. The interaction between all of these factors, the meat protein and the other ingredients is extremely complex and no universally reliable, predictive models exist. Ultimately, experience and testing are required to optimize the process.

STUFFING

Unfortunately, many people think of stuffing as a mere materials handling exercise. While the materials handling aspects are important, a poorly designed and/or operated stuffing system can significantly damage the ability of protein to bind fat and water and can drive significant variability throughout the rest of the process by delivering sub-optimal or inconsistent product dimensions. These dimensions ultimately affect the cooking and chilling rates, the ability to fit the finished product into the package and product weight control.

In nearly every processing system, meat is pumped and flows through pipes. Therefore, stuffing is an exercise in fluid dynamics. Understanding and applying the principles of rheology and fluid flow to the design and operation of these systems will help reduce damage caused by shear while minimizing variability in flow rate.

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Shear is detrimental to meat. Shear gets imparted to the meat any time it travels through a pump or pipe. The amount of shear depends on a number of factors including pipe diameter, length of pipe, number of elbows, type of pump and flow rate. Even the condition of the pipes and pumps can have a noticeable impact. As the amount of shear increases, damage to the meat's ability to bind fat and water increases. The amount shear that a product can withstand before failing is a function of the formulation. Failure due to excessive shear is typically manifested as rendering and purge. The best approach to preventing the negative effects of shear is through proper design and maintenance of the stuffing system.

Shear does more than disrupt the stability of the meat. Meat is a shear thinning fluid - the viscosity of the meat decreases as the amount of shear increases. As the viscosity changes, the flow rate will change. This variation in flow rate will translate into variability in the weight filled into casings and forms.

Ultimately, the stuffing system must deliver a known and repeatable amount of meat into consistent volume without damaging the meat. Variability in the stuffing system, translates into variability of product dimensions. If product dimensions are not consistent then the thermal process will not deliver consistent results, the product may not fit properly in the slicer orifice and/or may not fit correctly in the package. A sound understanding of rheology and fluid flow dynamics is important to achieve the optimum design and operation of stuffing systems.

CHILLING

Chilling involves more than getting the product cold in compliance with regulations. Proper chilling makes the product easier to slice, load in the package and improves consumer acceptance by reducing the amount of purge in the package and/or excessively wet product.

The chill process establishes the "mechanical" properties of the product necessary to provide best slicing performance and/or handling into the package. The product must be able to withstand the rigors of slicing and/or handling without damage. The product temperature determines these mechanical properties. Depending on the product, the optimum temperature may be above or below the freezing point of the product.

Understanding the product freezing point is critical in optimizing the chill process. Chilling to below the freezing point provides considerable rigidity but at the expense of ice formation within the product. Chilling to above the freezing point avoids formation of ice but gives a less rigid product. Chilling to the freezing point is rarely advisable because it results in severe ice damage without providing significant rigidity to the product. The right condition depends on the product design.

The formation of ice within the product during chilling needs to be carefully addressed. The first step is to know the freezing point of the product. Any process that chills meat to the freezing point and lower results in ice formation. Whole muscle products like ham are particularly susceptible to ice crystal formation. These ice crystals tend to multiply and grow over time, damaging the product appearance, causing purge in the package and excessively wet product. Sausage products tend to be more tolerant of freezing as long as the product does not remain at or near the freezing point for an extended period of time.

The temperature and heat transfer rate during chilling must be optimized to insure that the mechanical properties of the product are adequate for slicing and handling through packaging. The relationship between the chill process and the dynamics of ice crystal formation and propagation within the product are major factors in the performance of the product after thermal processing. A properly designed and executed chill process will allow for maximum yields while preserving product quality.

CONCLUSION

Understanding the physics associated with manufacturing processed meat products helps provide the best product to the consumer while ensuring optimum product cost. Therefore, the design of the process should receive significant attention during the development and production of meat products, with particular attention being paid to the mixing, stuffing and chilling steps of the process.