Non-Meat Ingredients for Meat Processing

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Introduction

Because of characteristic textures and flavors, the region from which meat products originate can be easily identified. However, basic formulations tend to evolve to account for changing economic conditions, raw material availability, consumer trends, food safety concerns, and adaptation from one region to another. In the US, innovative processors have formulated fat-free meat products to satisfy the need of the health-conscious consumer. In Peru, fat replacement is needed because animal fat is difficult to find. In Mexico, as well as Central and South America, meat processors are achieving up to 300% extension in frankfurters and hams. Highly extended meat products are needed in some parts of Europe while other areas continue to restrict the use of ingredients to maintain a "standard of identity". In parts of Asia, shelf-stable ham sausages are popular. In each of these regions, the meat proteins are required to provide a functionality that may need to be enhanced or supplemented by non-meat ingredients.

Non-meat ingredients can be divided into those added to enhance functionality of the muscle proteins, or those added as an additional "system" to aid in the retention of moisture and modify texture. The tolerance of a meat system for a binder is limited by either competition for moisture or a disruption of the meat gel structure (Comer and Allan-Wojas, 1988). Meat proteins require water to form a strong gel. Added ingredients should not compete with meat proteins for water. On the other hand, highly extended meat products require a strong binding system because more than enough water is available. Competition for water is still prevalent in such a meat mixture where full functionality of the ingredients requires complete hydration. To take advantage of the unique functionalities of all ingredients, or potentail synergy, a change in the traditional process procedures may be required.

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Ingredients for Muscle Protein Functional Enhancement

Salts

The salt-soluble myofirillar proteins are responsible for the water and fat binding properties of meat. Some of the most basic ingredients used in meat processing promote these properties. As the name implies, salt can aid in the extraction and modification of meat proteins for enhanced functionality. The action of salt during meat processing are well documented in the literature and will not be elaborated in this article. However, not all salts are created equal. Sodium chloride is probably the most common ingredient used in meat processing. Potassium chloride is used when formulators are seeking ways to reduce sodium in their products. Sodium chloride is more effective than potassium chloride in promoting meat protein functionality, requiring some adjustments during processing when formulating for low sodium products. Potassium also has a slight bitter flavor associated with it that will restrict is use. The amount of sodium chloride used in meat varies considerably depending on the product. However, the differences are primarily due to other properties of salt, such as flavor and microbial stability, rather than protein functionality.

Phosphate

Phosphates are another common ingredient used in meat processing to promote the functionality of meat proteins. Alkaline phosphates are used primarily to improve moisture retention capabilities. The hydrophilic character of protein is developed through a series of positive and negative charges. As the pH of the environment changes, the ratio of positive to negative charges inherent to the proteins also change. As the number of positive charges equal the number of negative charges on the protein molecule, the ability to hold moisture is reduced. Alkaline phosphates increase pH, promoting an inequality of positive and negative charges, resulting in more water retention capabilities. At the same time, the higher pH can pose additional challenges to the meat processor. Alkaline pH tends to promote the heat stability of pigments resulting in a retention of a pink color even after cooking. A high pH also slows the reaction for cure color formation in products containing nitrite. Acid phosphates (sodium acid pyrophosphate, for example), can reduce the pH in meat. This can promote the cure color formation in frankfurters, but has detrimental effects on yield. For these reasons, blends of different phosphates resulting in a neutral pH are available. Areas such as Europe restrict the use of phosphate based on the pyrophosphate content, while other areas restrict the amount in the finished product. Phosphates are generally used at levels below 0.5%.

Transglutaminase

One of the newer, emerging ingredients included in this category is the enzyme transglutaminase. Transglutaminase is capable of promoting protein interactions within a meat product for enhanced textural properties. It is well known that surimi will form a stronger, more elastic gel if allowed to incubate prior to heating. This phenomenon is believed to be due to the actions of transglutaminase. Endogenous transglutaminase is calcium dependent and catalyzes the reaction between the g-carboxyamide group of glutamine residues and primary amines (Folk and Chung, 1973). An extracellular microbial transglutaminase produced by a variant of *Streptoverticillium mobaraense* has been discovered (Ando et al., 1989; Washizu et al., 1994) allowing the use of transglutaminase to become economically feasible. An interesting characteristic of the microbial transglutaminase is that the catalytic property is now calcium independent. This microbial transglutaminase has been applied experimentally to polymerize soy proteins, conalbumen, rabbit myosin, carp myosin, and beef myosin (Muguruma et al., 1990; Tanaka et al., 1990). With the addition of transglutaminase (0.2%), maximum polymerization will occur between 2-3 hr holding time (Lee et al., 1997).

Ingredients Added for Moisture Management and Textural Modification

Proteins

Soy proteins are the most utilized non-meat protein in meat formulations around the world. There are three basic soy protein products used for processing - soy flour, soy concentrate, and soy isolate. Flour, concentrates, and isolates are categorized based on their moisture-free protein contents of 50%, 70%, and 90%, respectively. The most recent development in soy protein technology is the formation of functional concentrates. Traditional soy concentrates are produced by removing the soluble carbohydrates from defatted flour through aqueous alcohol extraction. Subjecting defatted soy flour to an acid leaching process creates a concentrate with higher soluble protein content, further improving the functionality of the proteins. Functional properties can be further improved by subjecting traditional concentrate to a heat treatment combined with high shear to create a highly aggregated soluble protein with a low flavor profile. Isolated soy proteins are used at levels of 1 - 2%, where concentrates approach levels as high as 11%.

Milk proteins are also used in meat products throughout the world. Nonfat dry milk, sodium caseinate, and whey protein concentrates are used as emulsifiers and water binders. Sodium caseinates are used for ham production in Mexico, helping to retain moisture. In some parts of the world, whey protein concentrates are finding uses as meat replacers in sausages. Reported benefits of milk proteins are smooth textures and bland flavors as well as water and fat binding. Caseinates do not have gelation properties and therefore will not bind meat pieces together. However, they do contribute to the overall firmness of the product (van den Hoven, 1987). Imm and Regenstein (1997) reported an interference in emulsion stability with the addition of sodium caseinate or milk protein isolate, but found no influence with the addition of whey protein isolates and concentrates. Recommended use levels are between 0.5 and 2.0%.

Hydrolyzed proteins are being used in the meat industry for flavor enhancement as well as water binding capabilities. Hydrolyzed soy protein, hydrolyzed gelatin, hydrolyzed vegetable protein, and hydrolyzed milk protein are a few of the more common hydrolyzed protein used in meat processing. The action of hydrolysis produces shorter chain proteins and free acids that act as flavor potentiators. In addition, because they are proteins, there are some moisture retention abilities that help manage moisture and bind fat. Most hydrolized proteins are used at levels between 1% and 2%.

Blood proteins are used in various countries due to their water binding ability and color contribution. Dry blood protein contains approximately 60 - 70% protein and is a good emulsifier and water binder. Meat processors in the US are less likely to use blood proteins due to consumer acceptance. These proteins are recommended to be used at levels not exceeding 1% due to flavor contributions.

Another binding system derived from blood is being used to bind fresh meat pieces without the use of heat or other binders. Fibrimex®, marketed by FNA Foods, Inc., is a system utilizing the binding function of fibrinogen and thrombin. Once the meat pieces are completely coated with a mixture of fibrinogen and thrombin, they are placed in a casing and allowed to set for 6-8 hours at refrigerated temperatures. The result is a cold set bind, allowing for the slicing and cooking of uniform cuts of meat. Fibrimex® can improve the portion control steak yield of beef tenderloins to as high as 99%.

Gelatin is a very common ingredient for meat processors and is mainly used as a water binder and gelling agent. In canned meat products, gelatin is used to gel juices lost from meat products during cooking. Some processors will use gelatin to stabilize emulsion-type products. Gelatin is the product of choice for jellied meat loaves. For this application, gelatin will comprise 3-15% of the formulation. In other products, gelatin will be used at 0.5-3%.

Dindre is an ingredient that is primarily found in Europe and is comprised of dehydrated meat protein from pork and beef skin and bone. The main functionality of dindre is to swell and bind water, but it does contribute to other properties such as fat binding and cohesiveness. The average protein content is 80-85%.

Carbohydrates

Starches. There are a wide variety of carbohydrates available to meat processors, and the category is growing daily. Starches are the most widely used carbohydrate because of economics and availability. Starches can be obtained from a variety of sources and can have a wide range in functionality. The type of starch used in any region is largely dictated by the economics and availability. The most common starches in the meat industry originate from potato, corn, wheat, tapioca, and rice. Starches can bind water (two to four times their weight), provide various degrees of freeze/thaw stability, and contribute to texture. Starches will generally provide a firmer texture in meat products.

The functionality of a starch is obtained upon gelatinization. At this point, the granule swells and loses birefringence with an increase in both clarity and viscosity. The amylose molecules dissolve and will reassociate to form a gel. Starches with high amounts of amylopectin, such as waxy maize starch, will not gel or weep after gelatinization. Tapioca, with a small amount of amylose, will form a soft gel when gelatinized. High amylose starch will set to a very stiff gel. Native potato starch will absorb more water compared to other native starches, has a lower gelatinization temperature, and will form a soft gel upon cooling.

Modification of starches is accomplished to enhance or quell some of the inherent properties of the native starches. Cross-linking of starches control texture and provide heat tolerance. Starches are freeze/thaw stabilized through the addition of anionic groups to block molecular association.

Unless starches reach their gelation temperature during processing, texture and water binding functions are reduced. Although the gelation temperatures of various starches in water are easily reached during the normal heat process, actual gelation temperatures in meat products may be elevated. Comer et al. (1986) used light microscopy, SEM and TEM to show corn starch and wheat starch granules in wieners. In water, the starch granules lose their birefringence at 60°C and start merging in the temperature range 60°C to 70°C. However, in meat applications cooked to 72°C, most of the starch granules were discrete and several possessed birefringence. It was shown that this may be due to the result of the limited moisture environment in the comminuted meat products. Pre-gelatinized starches may be useful for some applications. These starches are heated to achieve the gelatinization temperature prior to adding to the meat product. These starches will build viscosity rapidly in a meat system which can also affect the machinability of the raw meat mixture. Starches are used at various levels throughout the world to as high as 18%.

Maltodextrins are defined as non-sweet saccharide polymers having a dextrose equivalent less than 20. Some of the benefits promoted for maltodextrins are no flavor contribution, cold water soluble, helps to manage moisture, and enhances meat texture through interference with myosin gelation. Maltodextrins are have been found in low fat/high moisture products.

Fiber Sources. Both oat bran and oat fiber increase moisture retention. Oat bran also has the added benefit of improving mouthfeel. There are two USDA patented products for use as fat replacers in all types of foods. The first, oatrim, has been used in low fat ground beef, hot dogs, and bologna (Inglett, 1990). Oatrim is an enzymatically hydrolyzed flour from various grains. Like other carbohydrates, it can form a gel with water. The second is Z-trim, made from seed hulls (oats, soybeans, rice, and peas) or bran (corn or wheat). The gels made with Z-trim can be altered in their smoothness by adjusting particle source and size (Inglett, 1996)

Gums. There are many types of gums available for meat processors and it becomes increasingly difficult for a processor to feel confident that they have chosen the right one. Based on an article authored by Foegeding and Ramsey (1987), gums selectively affect various textural and water binding properties. A combination of gums may be needed to achieve the desired product quality. Gums can be cold water soluble or hot water soluble. Gums can be sols at hot temperatures and gel upon cooling, sols at cold temperatures and gel upon heating, sols at all temperatures, or can be made to gel that are stable at all temperatures.

Alginates are extracts from brown algae and are used as gelling agents, syneresis control and mouthfeel. The main advantage of alginate is its ability to form heat stable gels that are set at room temperatures. Means and Schmidt (1986) used alginate in conbination with calcium carbonate to bind meat pieces together in the raw state. This approach allowed for the manufacture of restructured steaks without the use of salt or the need for freezing during distribution.

Carrageenan is a hydrocolloid originating from selected red seaweed. The usefulness of carrageenan is based on its ability to manage moisture (20X - 24X) and texture in many food products. There are three general types of carrageenans, categorized based on gelling properties. Kappa and iota carrageenans are the more common carrageenans used in meat processing, while lambda is a nongelling carrageenan generally used for suspension of ingredients in other food products. In most cases, carrageenan is used at levels less than one percent and needs to be heated to achieve solubility. Kappa will form a more firm texture while iota will give a more elastic texture. Blends of different carrageenans allow for adjusting textures according to need. The gels resulting from the heating and cooling of carrageenan are heat reversible.

Locust bean gum is being used in the meat processing industry in areas such as Europe, Asia, and Latin America. Its use in salami, bologna, and other sausages helps develop homogeneity and smoothness. When used in hams, the primary functionality appears to be for purge control during storage.

Konjac is the generic name for the flour formed from grinding the root of the *Amorphophallus konjac* plant (Elephant yam). Konjac swells and hydrates to form a highly viscous aqueous solution. The time required to hydrate konjac can be reduced by increasing temperature. Konjac is basically a non-ionic polysaccharide that will not gel after hydration. Unique to konjac is the ability to form a heat stable gel when treated with an alkali to remove acetyl side groups. The removal of the acetyl groups allows binding within the framework and develops a gel that is heat stable to retort tmperatures. Konjac is used at very low levels in meat products for water retention and textural modification. Konjac and associated patents are marketed by FMC Corporation, Philadelphia, PA under the brand name Nutricolâ.

Xanthan is a product of microbial fermentation (*Xanthomonas campestris*). Because of its ability to produce high viscosity at low concentrations, xanthan is used primarily as a suspending agent for ingredients. However, in combination with other gums, xanthan can impart some unique functionality.

Gellan gum is the generic name for the extracellular polysaccharide formed by the bacterium *Sphingomanas elodea*. Gellan gum is proprietary to Kelco. Gellan gum needs to be heated to approximately 80°C for solubility and requires cations to cause gelling as the solution cools. By controlling the concentration of cations, the gel obtained can be a soft elastic gel or hard and brittle. Gellan is compatible with other gums.

Curdlan is also a gelling agent produced through microbial fermentation (*Alcaligenes faecalis* var. *myxogenes*). Curdlan will form a heat reversible gel when heated to 60°C and cooled to below 40°C. However, unique to curdlan, if heated to a temperature above 80°C, a gel stable to retort temperatures is produced. Curdlan is compatible with other carbohydrates. The addition of starch to curdlan will lower gel strength, but is effective in controlling syneresis, which increases with increasing temperatures and decreases with higher concentrations of curdlan. Curdlan is currently being marketed by Takeda USA, Inc., Orangeburg, NY, under the tradename *Pureglucan*ä.

Chemically Modified Plant Materials

Cellulose Derivatives. Cellulose based material have found limited success in meat products. Cellulose gum or sodium carboxymethylcellulose (CMC) is generally used to thicken, suspend, stabilize, gel, and modify flow characteristics of aqueous suspensions. CMC helps to minimize syneresis by binding water. Methylcellulose and hydroxymethylcellulose gel when heated and return to solution when cooled. These ingredients are finding uses in meat products requiring heat stability, such as those used in soups and stews. Microcrystalline cellulose, produced by acid hydrolysis, may contain a small amount of CMC as a dispersing aid. MCC can also be processed with alginates or carrageenan. MCC is being used as an additive in low fat ground meat systems to re-establish juiciness and mouthfeel.

Pectins. Pectins are widely used as gelling agents in many food products. Pectins are water soluble and result in a viscous solution. High methoxy pectin is well known as a gelling ageent but will only gel under strict conditions of sugar concentration and acidity. Low methoxy pectins form gels through calcium ions. The use of pectin in meat processing is limited. However, Slendidâ, a pectin-based fat replacing system marketed by Hercules, has applications in low fat meat spreads. Slendidâ is used at approximately 2% in these applications.

Using Non-meat Ingredients

Non-meat ingredients can provide a variety of textures and flavors. Economics, variety, convenience, and health oriented diets are making consumers more receptive to non-meat ingredients in meat products. Achieving full functionality from any ingredient requires an understanding of how conditions affect its performance. It is very rare that one non-meat ingredient will provide all the characteristics desired in a meat product. Combinations of ingredients may be necessary. Combinations of ingredients that show unique synergy water may not be realized without a change in the conditions surrounding the process. These conditions may be outside the normal process for meat products. Efforts to develop the next generation of meat products will require a knowledge of how ingredients interact with each other and how processors can take advantage of those interactions.

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