

# New Technology for Low-Fat Meat Products

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## Introduction

Functional properties of meat systems are primarily dependent on the interaction of the protein fraction with the other components. These interactions (protein-water, protein-lipid and protein-protein) have a direct impact on how well the meat system binds water, stabilizes fat and produces desirable sensory textural properties and cohesion. Consumers continue to desire meat products that are healthy (reduced fat/calories/sodium) and convenient (microwaveable and user-friendly packaging) at a reasonable cost, but not at the expense of reduced palatability. In products with lower fat levels (higher water) or reduced sodium levels, however, the functionality of the traditional myosin heat set matrix may be limited due to low ionic strength and palatability and safety may be compromised. The development of products to meet current consumer demands offers meat processors opportunities for continued markets and profit but also opportunities for problems. In many respects, technology for production of low-fat meat products is not new. However, careful attention must be paid to all steps in production, including selection of meat and nonmeat ingredients, processing procedures and equipment to produce products with desired sensory properties, shelf-life and safety. Judicious choice of nonmeat ingredients is especially important.

## Product Composition/Labeling

Meat processors can respond to consumer demands for leaner, healthier foods by changing product composition and carefully controlling fat levels (Table 1). The development of 90% and 95% fat-free meat products (e.g. ham, cooked beef and poultry) in recent years and an increase in demand for these products emphasizes not only the interest in low-fat products but also the willingness of consumers to pay a premium for low-fat meat items (Pearson et al., 1987).

In some parts of the United States, as much as 89% of ground beef sold in retail stores now contains 22.5% fat or

less (Anonymous, 1989). However, because of the importance of fat to sensory properties of ground beef, sale of ground beef with less than 10% fat is not yet a major part of the market. Therefore, current research efforts have been directed at production of low-fat ground beef items with acceptable sensory properties (Huffman and Egbert, 1990).

Recent changes in USDA regulations permit substitution of water for fat in cooked sausage (USDA, 1988), which facilitates the production of lower-fat frankfurters, weiners, bologna, etc. Previously, it was most economical to produce cooked sausages with 30% fat, 11% protein, 54% water, 3% salt and 2% sweeteners, spices and cures. However, due to recent regulation changes, products can now be produced with 10% fat, 12% protein, 72% water, 2% salt and 4% sweeteners, spices and cures as water can now be substituted for fat. Economic advantages of higher added water will only be valid if the water is not lost during heat processing (Claus et al., 1989).

In an effort to attract the "health-conscious" or "active-lifestyle" consumer, companies could make nutrition-related labelling claims for these products, using words such as "reduced fat" or "90% fat-free." A review of the general labelling requirements is presented in Table 2. Note that in order to use the term "lean," the meat source (before addition of water) must meet the requirements.

A potential nutritional labelling change involves expressing fat in a product as a percentage of calories. The American Heart Association and the US Department of Agriculture have recommended that dietary fat be limited to no more than 30% of all calories consumed. When fat is expressed as a percentage of calories, meat products may not fare well

**Table 1. Red Meat Products in Which Leanness can be Controlled by the Processor.**

	<i>Billion Pounds<sup>a</sup></i>
Hams: boneless	1.1
Beef: cooked	.5
Beef: ground and patties	4.1
Franks and Weiners	1.5
Bologna	0.6
Liver, Loaves and Other	1.1
Other sausage	0.4
Fresh sausage	1.0
Dried and Semidried Sausage	<u>0.4</u>
	<u>10.7</u>

<sup>a</sup> Meat products processed under federal inspection, 1987  
 Source: US Department of Agriculture (Meat Facts American Meat Institute, 1988 edition).

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**Table 2. Requirements For Permitted Labelling Claims.<sup>a</sup>**

<i>Claim</i>	<i>Lean</i>	<i>Extra Lean</i>	<i>Lite</i>	<i>Lower Fat</i>
Emphatic	≤10% fat* (before water addition)	≤5% fat* (before water addition)	≤40 Kcal/100g ≤10% fat ≤10% breading ≤35 mg Na/100g	—
Comparative	—	—	≥25% reduction in calories, fat breading or sodium from comparison	≥25% reduction in fat from comparison

\*For ground beef, ≤22.5% fat

<sup>a</sup> Modified from Leddy, 1988

(Table 3). Even products that are 94% fat free and very nutrient dense may contain over 50% of calories from fat. In order to meet the "30% limit" for consumers, processors have several options. They could make the products leaner (e.g. 98% fat-free) by using more lean meat (\$\$\$) or they could dilute out the calories from fat with addition of extra nonmeat proteins or complex carbohydrates to allow a more balanced protein/fat/carbohydrate profile.

### Meat Ingredients

The production of low-fat meat products will require use of leaner meat ingredients. Processors can vary the species of animal utilized and the muscle source which may vary considerably in connective tissue and fat content. Sophisticated methods are being developed to separate lean from fat and this should provide new raw materials for lean product manufacture. However, there still remains much handwork to be done to prepare high quality lean processed products. By-products, which are typically low in fat, can be used but must be clearly labeled on the finished product.

### Nonmeat Ingredients

#### Sodium Chloride

Consumers are concerned about the complexity of labels of their foods as well as the level of certain ingredients, such as salt. Therefore, processors can vary the salt level and can substitute potassium chloride for part of the sodium chloride in some products. However, many products still require at least the equivalent of 1.5% sodium chloride. This would be especially important for products in which water has been substituted for fat since the ionic strength of the meat system has been diluted and could result in products with an impaired heat set myosin matrix. In reduced sodium products, it is often necessary to add other components to retain a long shelf-life for the product. Sodium lactate is proving to be a valuable compound for enhancing shelf-life (Papadopoulos, 1990).

#### Phosphates

As a processor reduces the level of salt, it is almost essential to utilize phosphates. Phosphates are limited to

**Table 3. Calculations of Fat Content (100g of product).**

<i>Product</i>	<i>Kcal/oz</i>	<i>Source</i>	<i>g/100g</i>	<i>Kcal/100g</i>	<i>% of calories</i>
A 30% fat	90	Protein	11	44	14
		Fat	30	270	<b>84</b>
		Carbohydrates	2	8	2
				322	
B 94% fat-free	30	Protein	11	44	41
		Fat	6	54	<b>51</b>
		Carbohydrates	2	8	8
				106	
C 98% fat-free	20	Protein	11	44	63
		Fat	2	18	<b>26</b>
		Carbohydrates	2	8	11
				70	
D 96% fat-free	34	Protein	11	44	37
		Fat	4	36	<b>30</b>
		Carbohydrates	10	40	33
				120	

0.5% of the finished product and contribute greatly to enhancing the functionality of the meat proteins by raising the ionic strength, dissociating proteins and adjusting the pH to the proper level of about 6.0.

### Nonmeat Proteins

Nonmeat proteins may serve many purposes in low-fat meat products. They contribute to water and fat binding and also may contribute to flavor and serve as a texture substitute for fat. For example, milk proteins are especially important in liver sausage as they contribute a mild and creamy flavor and smooth mouthfeel. Proteins do not appear to tie up the water-soluble flavor components of a meat product as much as carbohydrates do. The use of nonmeat proteins in processed meat has been an ongoing area of research and the subject of numerous reviews (Mittal and Usborne, 1985; Endres and Monagle, 1987; Foegeding and Lanier, 1987; van den Hoven, 1987; Visser and Thomas, 1987; Barraquio and van de Voort, 1988; Hoogenkamp, 1989).

Proteins from soy, milk, yeast, plasma and meat can be hydrolyzed and added to various meat products. Hydrolyzed proteins contribute a brothy or meaty note to injected roasts and other products. Up to now, many of these compounds have been labeled as flavorings but this will probably change in the near future as a final rule may take effect August 28, 1990 which requires many of these compounds to be listed by their common or usual names in the ingredient statement on the label (USDA, 1990b).

Mustard can be used to enhance water binding capacity and peelability of casings. The USDA FSIS continues to permit a 1% level of nonmeat protein to be utilized to calculate the level of added water, based mainly on the long-term use of mustard as a protein component in meat products (USDA, 1990c).

### Sweeteners

Simple sugars, such as sucrose and dextrose, are important in processed meats, not only for their sweetening effects but also for their moderation of saltiness. Many sweeteners, especially low dextrose equivalent (DE), corn syrup solids (DE  $\geq 20$ ) and maltodextrins, (DE  $< 20$ ), can contribute to water-binding capacity. Corn syrup solids and maltodextrins have long polysaccharide structures and act similar to starch, but result in products with a cleaner flavor and mouthfeel. However, it must be remembered when using compounds that have dextrose that these reducing sugars will contribute to nonenzymatic browning and can result in unwanted browning in a meat product.

### Starches and Gums

Starches and polysaccharide gums are very effective water-binding and texture-modifying agents and are widely used in a wide range of food products. General properties of gums and starches available to the food industry have been summarized in several review articles (Sanderson, 1981; Ingoe, 1982) and in a three-volume series of books (Glicksman, 1982). In addition, a great deal of current information can be obtained from the proceedings of an interna-

tional conference on gums and stabilizers held bi-yearly (Phillips et al., 1982, 1984, 1986, 1988).

There is a lot of interest in the use of starches and polysaccharide gums in low-fat or reduced sodium, high-yield meat items but limited published research available. In order to select the "best" hydrocolloid for a meat application and to optimize its functionality in a meat system, it is necessary to thoroughly understand the specific properties of various starches and polysaccharide gums.

### Starches

Starch is the most commonly used food hydrocolloid and occurs widely in nature. Starches are carbohydrate polymers of glucose and usually contain amylose and amylopectin components. Amylose is a linear, straight-chain,  $\alpha$ -1,4 glucopyranose polymer; amylopectin, on the other hand, is a random-branched configuration of  $\alpha$ -1,4 glucopyranose with periodic branching of sidechains with 1,6 linkages (Wurzburg, 1986). Granule size, shape and size distribution and the amylose/amylopectin ratio of a starch varies with botanical source (potato, corn, wheat, tapioca, rice) (Oakenfull, 1987).

Gelling properties of starches are dependent upon the amylose component which, because of its structure, can form hydrogen bonds with neighboring molecules to build up a three-dimensional network. The highly branched structure of amylopectin does not allow close physical association between molecules and thus prevents gelation. During starch gelatinization, a number of changes take place simultaneously or successively, which include granule swelling, disruption of crystalline regions, loss of birefringence, increase in viscosity and possible fragmentation of the granules (Wu et al., 1985). Starch gelatinization can be influenced by water-to-starch ratios, lipids, sucrose, salt content and processing conditions (Lund, 1984).

A number of starches available today are physically and/or chemically modified (Luallen, 1985; Langan, 1986). Pregelatinization of starches renders them cold water swelling and involves simultaneous cooking and drying procedures. Starches may also undergo a variety of chemical modifications to alter their functional properties, for example to improve freeze-thaw stability, reduce syneresis and/or to enable the starch to withstand high shear or heat conditions (Langan, 1986).

Table 4 summarizes some of the current meat research with starches. Starches are commonly added to emulsion-style meat products and are popular not only for their functional properties but also for their low cost relative to alternatives. Starches help to stabilize meat batters by absorbing or binding excess water but do not participate in the actual emulsifying process or improve the water-binding capacity of the meat itself (Schut, 1976). The use of these binders thus enables the producer to add more water than the meat emulsion itself could hold.

Potato starch swells at a faster rate than the other starches and, in highly extended systems, may give the most stable homogenates (Comer, 1979). However, under retort conditions, potato starch granules rupture more rapidly and consequently produce softer products than other native starches.

**Table 4. Outline of Selected Literature on Uses of Starches in Meat Batters and Chunked and Formed Meat Products.**

<i>Reference</i>	<i>Polysaccharide(s)</i>	<i>Meat Product</i>	<i>Experimental Conditions</i>	<i>Major Effects</i>
<b>A. MEAT BATTERS</b>				
Bushway et al., 1982	potato starch and/or wheat flour	frankfurters (26% fat; 13% protein)	Starches added at 3%	Potato based more tender; all equally acceptable with similar yields.
Comer et al., 1986	wheat flour modified corn starches various proteins	frankfurters (23-25% fat; 10-15% total protein; 2.6-2.9% NaCl)	Test ingredients at 7.5% (6.8% solids)	All fillers improved stability; starch fillers produced the firmest texture.
Bonnefin & Baumgartner, 1988	various starch-based binders (7)	Australian "small good" (60% meat; 37% water; 2% NaCl; 0.26% phosphate)	Binders at 3%, 6%, 9%; Products cooked to 65, 70, 75°C.	Greater water holding as binder levels increased; highest compression force at 70°C.
Skrede, 1989	potato flour wheat starch corn starch tapioca starch modified potato starch	meat batters (20-21% fat; 8.6% protein; 1.8% NaCl)	Added at 4.0% starch content. Cooked at 65-85°C and stored at 5°C or -25°C.	Potato flour rated best; modified potato starch had improved freeze/thaw stability.
Claus & Hunt, 1990	wheat starch modified waxy starch sugarbeet pulp fiber pea fiber isolated soy protein	bologna (10 or 27% fat; 11% protein; 2.3% NaCl; 0.5% phosphate)	Test ingredients at 2-5%.	Treatments with fibers or starches had lower purge but similar cook loss to low-fat control. Dietary fibers more effective than starches in increasing firmness, but fibers had more perceptible graininess.
<b>B. CHUNKED AND FORMED MEATS</b>				
Perejda, 1990	native and modified starches (10)	restructured beef rolls (Algin/Ca or 1.5% NaCl/0.30% phosphate)	0-8% starch; 0-30% added water	Cook-up starches more effective than instant starches.

## Alginates

Alginates are the major structural polysaccharides of brown algae of the Phaeophyceae family. Alginates are linear polymers composed of D-mannuronic acid and L-guluronic acid in three types of block structures: poly- $\beta$ -D-mannuronic acid (M), poly- $\alpha$ -L-guluronic acid (G) and mixed (MG) blocks containing both acids (McDowell, 1986). The solution properties of a particular alginate depend on the ratio of mannuronic to guluronic acid and the block structures.

Alginates differ from other gel-forming hydrocolloids in that they form chemically rather than thermally induced gels which are thermostable (McDowell, 1986). Alginate gels are formed by the intermolecular association of polyvalent cations (except magnesium), with predominately G-block regions of the polysaccharide molecule. Calcium ions are superior to other polyvalent cations in their interaction with alginates (Sanderson, 1981). Reviews by Morris (1986) and Oakenfull (1987) describe many of the currently held theories

of the alginate/calcium gelation mechanism.

In meat systems, alginates and the alginate/calcium gels have been used as texture-modifying agents (Abd El-Baki et al., 1981), as edible protective coatings and as a mechanism for binding of restructured meats. Kester and Fennema (1986) have reviewed the use of alginate as an edible protective coating and described several studies in which alginate coatings formed by diffusion setting inhibited dehydration of carcasses and various meat cuts. Studies of sensory attributes of precooked, calcium alginate-coated pork patties (Wandstedt et al., 1981) indicated that calcium alginate coatings may also be useful in preventing warmed-over flavor.

The unique reaction of alginates with calcium ions in the absence of heating has proven useful as a raw, refrigerated binding mechanism as well as a cooked binding mechanism for structured meat products (Means and Schmidt, 1987). This binding system which uses sodium alginate, a calcium

source and organic acids, is approved for commercial use in red meats (USDA, 1986) and in poultry products (USDA, 1990a). Factors that have been identified which influence bind and sensory properties of algin/calcium structured meat products include: alginate level, calcium ion source and level, type of acidulant used and pH (Means and Schmidt, 1986; Means et al., 1987; Clarke et al., 1988). Addition of other polysaccharide gums, especially kappa carrageenan, may offer algin/calcium structured products increased yield without loss of bind (Shand et al., 1990; Table 6). Unlike conventional restructuring technology, algin/calcium structured meats do not require salt and phosphate for protein extraction and bind.

### Carrageenans

The term "carrageenan" describes a group of sulfated polysaccharides extracted from various red seaweeds. The three main carrageenan fractions are kappa, iota and lambda. All the fractions are composed of galactose residues sulfated to differing degrees and alternately linked  $\alpha$ -1,3,  $\beta$ -1,4 (Modliszewski, 1984). The kappa and iota fractions form thermoreversible gels; i.e., gel on cooling and "remelt" on heating while the lambda fraction does not gel.

Because of the ionic nature of these polymers, gelation of kappa and iota carrageenan is strongly influenced by the presence of electrolytes. Kappa carrageenan produces rigid, thermoreversible, high-strength gels in the presence of calcium ions. Kappa carrageenan and potassium ions form an elastic gel. Kappa carrageenan also shows synergism with other gums. Locust bean gum and xanthan gum when added to kappa carrageenan systems increase gel viscosity, strength and elasticity and reduce syneresis (Igoe, 1982). Iota carrageenan produces freeze-thaw stable, flexible gels and forms an elastic gel in the presence of calcium ions. Carrageenans available commercially for use in meat and other products are often a mixture of several carrageenan fractions, and may also contain locust bean gum, guar gum and cation sources, such as calcium lactate (Orovio et al., 1987).

Carrageenan can perform several different functions in meat products. Usually, however, carrageenans are used either for gelation of the sauce or broth surrounding the meat or of the liquid contained in the meat. Carrageenan can be used as a brine ingredient and introduced into meat products either by massaging or by multi-needle injection followed by massaging. It is recommended that carrageenan be added to the brine after dissociation of the salt and phosphates (Anonymous, 1984). Under these ionic conditions, the hydration of carrageenan is inhibited (Tye, 1988) and brine viscosity therefore is kept to a minimum.

Carrageenan has been tested as a water-binding agent in cooked ham (Anonymous, 1984) and other processed meats (Anonymous, 1985). Kappa carrageenan, a preferred binding agent in ham, resulted in products of good water binding during storage, good sliceability, decreased cooking losses and improved texture. Yield increases could be as high as 50% to 80% above green weight (Anonymous, 1984).

A number of low-fat processed chicken and turkey products now contain carrageenan. There is potential for the use of carrageenans, especially kappa carrageenan, in emulsion-style meat products and in restructured beef rolls. Current

research is summarized in Tables 5 and 6.

### Cellulose Derivatives

Cellulose is found in almost all land plants and is the structural material of the cell wall. Chemically, it differs from starch simply by having  $\beta$ -1,4 linked rather than  $\alpha$ -1,4 linked glucose units (Sanderson, 1981). For food use, celluloses may be modified to be water-soluble by placing substitutes along the chain. The properties of the cellulose derivatives can be controlled by varying the kind of substitute group, the uniformity and degree of substitution and the polymer length (molecular weight) (Henderson, 1988). Three major cellulose derivatives are carboxymethyl cellulose, methyl cellulose and hydroxypropyl methyl cellulose.

Food grade carboxymethyl cellulose (at least 99.5% pure), also called cellulose gum, has a high water-binding capacity and is an important bulking agent in dietetic foods. Carboxymethyl cellulose is generally used to increase product viscosity to stabilize other ingredients or to prevent syneresis. Carboxymethyl cellulose has been shown to minimize syneresis in alginate gels and in starch-based systems (Sanderson, 1981).

The methylated cellulose derivatives, methyl cellulose and hydroxypropyl methyl cellulose, have the unique property of reversible thermal gelation; i.e., they form gels when heated and return to their original viscosity on cooling (Krumel and Lindsay, 1976). These hydrocolloids are typically added to pies to retard juice boilover in cooking and to reduce absorption into the crust. In fried products, inclusion of methyl cellulose or hydroxypropyl methyl cellulose in the batter or breading may reduce oil absorption (Henderson, 1988) and can also improve adhesion of the batter or coating to the food product (Sanderson, 1981).

Cellulose derivatives have been incorporated in low-fat frankfurters and restructured beef rolls with limited success (Lin et al., 1988; Shand et al., 1990a; Tables 5 and 6).

### Seed Gums

Guar gum and locust bean gum are plant seed derivatives consisting of straight chains of D-mannose units with side branches of single units of galactose. Guar gum, with a mannose to galactose ratio of 2:1, is more highly substituted than locust bean gum which has a mannose to galactose ratio of 4:1, and hence is more soluble (Sanderson, 1981). Guar gum forms colloidal dispersions when hydrated in cold water while most grades of locust bean gum require hot water for complete dissolution.

Guar gum and locust bean gum give highly viscous solutions at low concentrations and are useful thickening, stabilizing and water-binding agents. Because of the nonionic nature of these gums, they are stable over wide pH ranges (1-10.5) and compatible with salts over a wide range of electrolyte concentration. As described previously, guar gum and locust bean gum synergistically interact with kappa carrageenan (Igoe, 1982). Synergistic interactions with xanthan gum have also been observed (Sanderson, 1982).

Published information on the effects of guar gum and locust bean gum in meat systems is limited. In an Australian publication, Jackson (1981) stated that guar gum may be used in comminuted meat products to absorb free water,

Table 5. Outline of Selected Literature on Uses of Polysaccharide Gums in Meat Batters.

<i>Reference</i>	<i>Polysaccharide(s)</i>	<i>Meat Product</i>	<i>Experimental Conditions</i>	<i>Major Effects</i>
Wallingford & Labuza, 1983	xanthan, locust bean gum, carrageenan, low methoxy pectin	meat batters (7% fat; 11% protein)	Gums at 0.2%	Water binding highest with xanthan; emulsion stability lowest with pectin.
Fox et al., 1983	xanthan, guar, locust bean gum, carrageenan, gum arabic	frankfurters (30% fat; 11% protein; 2% NaCl)	Gums at 0.5% of emulsion: Held in acid pickle for up to 28 days	Xanthan and carrageenan stabilized texture.
Whiting, 1984	xanthan gum, sodium alginate, various proteins	meat batters ("standard")	Gums at 0.1 and 0.3%; Varied NaCl (1.5 or 2.5%) and phosphates (0.05 or 0.10%)	Xanthan or alginate improved water binding but were detrimental to texture.
Foegeding & Ramsey, 1986	iota-carrageenan, kappa-carrageenan, guar, locust bean, xanthan, methylcellulose, locust bean:kappa carrageenan	meat batters (10 or 30% fat; 13% protein; 2.35% NaCl)	Gums at 0.2%; cooked to 40-70°C	Kappa-carrageenan increased hardness; xanthan decreased all textural parameters. Acceptability of low fat franks with or without carrageenan (kappa or iota) similar to high fat control.
Foegeding & Ramsey, 1987	iota-carrageenan, kappa-carrageenan, xanthan gum	meat batters (10 or 30% fat; 13% protein; 2.35% NaCl)	Gums at 0.5 and 1.0%; cooked to 50-70°C	Kappa most effective at increasing hardness. Xanthan decreased all textural parameters.
Zeuthen & Olson, 1987	kappa-carrageenans, kappa/lambda carrageenans, locust bean gum, guar gum, xanthan gum	meat batters (2% salt; 0.4% phosphate)	Gums or gum mixtures at 0.25 to 0.50%	Lowest jelly formation and best water holding in products with locust bean gum, kappa-carrageenan or kappa/lambda carrageenan.
Lin et al., 1988	carboxymethyl cellulose (four types)	frankfurters (14-15% fat; 16-17% protein) ? NaCl	Gums at 0.25%	Carboxymethyl cellulose decreased most texture parameters and offered no improvements in yield or stability.
Barbut & Mittal, 1989	iota-carrageenan kappa-carrageenan	meat batters (15-27% fat; 16% protein; 2.25% NaCl)	Gums at 0.4%; also added K <sup>+</sup> and Ca <sup>++</sup>	Addition of ions had minor effects on gum effectiveness; some differences in batter rheology noted.

restrict moisture loss during cooking and retard dehydration of cut slices. As a processing aid in meat canning, guar gum may be useful in preventing particle separation while the mix awaits filling. It may also be used to thicken gravy and control fat separation. In gelled products, it modified texture and retarded syneresis (Jackson, 1981).

Recent research on guar and locust bean gum addition to meat systems is outlined in Tables 5 and 6. In contrast to aqueous systems (Igoe, 1982), addition of locust bean gum and kappa carrageenan to low-fat meat batters (10% fat) did

not interact synergistically to increase textural strength (Foegeding and Ramsey, 1986), since addition of both locust bean gum and kappa carrageenan (0.1% each) produced similar textural properties to treatments with 0.2% locust bean gum or 0.2% kappa carrageenan alone.

### Xanthan Gum

Xanthan gum is a high molecular weight extracellular polysaccharide produced in a pure culture fermentation by

**Table 6. Outline of Selected Literature on Uses of Polysaccharide Gums in Chunked and Formed Meats and Ground Beef.**

<i>Reference</i>	<i>Polysaccharide(s)</i>	<i>Meat Product</i>	<i>Experimental Conditions</i>	<i>Major Effects</i>
<b>A. CHUNKED AND FORMED MEATS</b>				
Orovio et al., 1987	kappa-carrageenan; kappa + 30% locust bean gum; kappa + 30% locust bean gum + 10% calcium lactate; carrageenan mixture	Pressed hams (35% pump over green weight; 2.1% NaCl; 0.65% phosphate)	Gums added at 0.08% level (3.0% in brine)	All gum treatments similar in yield and texture; Cook losses were lower in injected and massaged products than massaging alone.
Shand et al., 1990a	kappa-carrageenan, iota-carrageenan, guar, locust bean gum, xanthan, gellan, carboxymethyl cellulose, methyl cellulose, low methoxy pectin, gum karaya	Restructured beef rolls (Algin/Ca and 1.4% NaCl/0.32% phosphate)	Gums at 0.5 and 1.0%; 15-30% added water (meat block)	Kappa-carrageenan improved cook yield and maintained (or improved) texture in both meat systems. Iota performed better in salt/phosphate products. Most other gums improved water holding but were detrimental to product texture.
Shand et al., 1990b	kappa-carrageenan	Restructured beef rolls (4-5% fat; 33% added water; 0.35% phosphate)	Gum at 0.5 and 1.0% Varied NaCl (1,2,3%) and temperature (63, 73, 83°)	Kappa-carrageenan improved yield and bind, decreased purge and was most beneficial at low salt levels (1.0%) and high product temperatures (83°C).
<b>B. GROUND BEEF</b>				
Huffman & Egbert, 1990	carrageenan; also hydrolyzed vegetable protein (HVP)	Ground beef (20% fat control; rest 10% fat)	Two lean ground beef products tested (1) 0.25% NaCl and 0.125% HVP (2) 0.50% carrageenan, 0.375% NaCl, 0.188% HVP and 3% water	The two lean ground beef products were similar in sensory properties to 20% fat control and more acceptable than 10% fat control.

the microorganism *Xanthomonas campestris* (Sanderson, 1982). Xanthan has a backbone of  $\beta$ -1,4 linked D-glucose units with side chains consisting of two D-mannose units and one D-glucuronic acids attached to every second glucose residue. In addition, approximately half of the terminal D-mannose units have pyruvic acid ketalically linked to the 4- and 6-positions and the D-mannose units closest to the backbone has an acetyl substituents on the 6-position (Sanderson, 1982).

Xanthan gum, because of its molecular structure, produces solutions with unique rheological properties. The viscosity of xanthan gum solutions is dynamic, depending on shear or mixing conditions. During low shear conditions, the viscosity is high; at high shear, the viscosity rapidly drops to a low level. The viscosity of xanthan gum solutions is stable in the presence of salt and over a wide range of temperature and pH conditions.

Combinations of xanthan gum and locust bean gum in

aqueous solutions form very elastic thermoreversible gels while xanthan gum and guar gum show synergistic increases in viscosity rather than gelation (Sanderson, 1982).

The effects of xanthan gum addition in low-fat or reduced-sodium comminuted meat systems have been studied by several researchers (Wallingford and Labuza, 1983; Whiting, 1984; Foegeding and Ramsey, 1986, 1987; Zeuthen and Olson, 1987). In general, these studies indicated that the incorporation of xanthan gum resulted in good water binding and low cook losses but adversely affected product texture (Tables 5 and 6).

### Other Polysaccharides

Chitosan (deacetylated chitin) is processed industrially from crustacean shell waste (Knorr, 1984) and is soluble in dilute hydrochloric acid or organic acids but is insoluble in neutral or alkaline aqueous solutions. While many polysac-

charide gums are neutral or polyanionic, chitosan is cationic.

Recently, St. Angelo et al. (1988) reported that the N-carboxymethyl derivative of chitosan effectively inhibited warmed-over flavor development in cooked ground beef. N-carboxymethyl chitosan has been reported to bind metals (Muzzarelli et al., 1982). Iron catalyzed, free radical oxidation of polyunsaturated phospholipids was inhibited in ground beef samples with 0.06 to 0.50% N-carboxymethyl chitosan as evidenced by decreases in hexanal concentration (direct GC analysis) and decreased TBA reactive substances (St. Angelo et al., 1988). Vercellotti and St. Angelo (1989) further reported that a trained sensory panel found decreases in "cardboardy" and "painty" off-notes and maintenance of the "cooked beef brothy" on-note in 2-day stored cooked ground beef samples. They also stated that the N-carboxymethyl chitosan distributed well in the meat matrix and was stable during cooking or heating. This application has been patented (St. Angelo and Vercellotti, 1989) and awaits further development and testing by the meat industry.

### Processing and Equipment

The complexity of processes and equipment needed to produce a wide array of low-fat products will depend on whether the product is a batter, patty, whole muscle or chunked and formed.

#### Comminutors

There is a wide range of equipment available to reduce meat particle size. Grinders, choppers, flakers and hand cutting are all utilized to reduce meat particle size. Generally, the higher quality the meat, the less the particle size must be reduced. New equipment on the market to desinew and remove bone chips can prove very valuable for upgrading lower quality meat to make it acceptable for the manufacture of high-quality comminuted meat products. For production of lean (10% fat) ground beef products, Huffman and Egbert (1990) found a slight improvement in sensory attributes through the use of a 3/16 inch (.48 cm) grinder plate rather than a 1/8 inch (.32 cm) plate.

#### Injectors

The use of injectors is extremely important in processing whole muscle meat products. Injectors will help to tenderize the product but may also distribute microbes throughout the interior of the product. Microbes may be a health hazard or may produce unsightly air pockets during heating. Therefore, excellent sanitation procedures must be practiced both in preparation of the material to be injected as well as with all the equipment, injectors and pumping lines for injection. For high levels of injection, (up to over 50%), it may be necessary to do two passes through an injector or hook injectors in tandem so that the material may be added to the solid product during two injection processes.

#### Mechanical Action

The use of various mixers, blenders, tumblers and mas-

sagers are often necessary to facilitate the distribution of added nonmeat ingredients throughout the product. This mechanical action should proceed at the lowest possible temperature without freezing any portion of the meat. Retention of any ice in the product after mixing could result in pockets of very low water-binding capacity and a very high purge in the finished product. There are mixers and tumblers on the market which have cooling systems built in them to prevent product temperature rise. In addition, the application of vacuum helps to produce finished products which have no airholes. The individual processor must select equipment based on product quality, cost of the equipment, throughput and durability.

#### Formers

A wide array of formers are available to produce everything from patties to chubs and entire roasts. The processor again needs to keep in mind the cost per unit, the filling rate, the adaptability to do on-line cooking or freezing and the dimension of the product that will be produced. Controlling the amount of air in the product may be very important to producing desired textural properties in low-fat products. For example, in some products the desired structure is very dense with no air, whereas for other products such as pork sausage patties, the structure should be more open to prevent excessive bind and rubberiness. After a product is formed, it is desirable to pass the material through a metal detector.

#### Cookers and Refrigerators

There are recent developments in cooking and refrigerating systems which can save energy, reduce pollution and increase throughput. Above all, it is important to assure microbial safety of the products which means that all product must be cooked uniformly and cooled quickly. Many meat products are vacuum packaged and cooked in the package. If the proper ingredient formulation and processing procedure has been followed, the product will have no purge in the package after cooking and can simply be labeled and sold. These products have a considerably enhanced shelf-life over ones that must be repackaged and surface pasteurized after purge is drained. Addition of nonmeat proteins, starches and polysaccharide gums may help to minimize purge.

### Summary

New technology for low-fat meat products requires an integrated effort in all steps of production from selection of meat ingredients, nonmeat ingredients to equipment choices in order to produce products with the desired functionality, sensory properties, shelf-life and safety. Nonmeat proteins and various polysaccharides may be useful water-binding and texture-modifying agents in low-fat, high added-water products or low-salt systems where the functionality of the myosin heat-set matrix may be impaired due to the reduced ionic environment. The goal is to sell more product by meeting consumer demands without creating new problems which may decrease profits.

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## Discussion

*C. Kasaback:* I have a question for Phyllis. You indicated that you used kappa carrageenan as a brine ingredient for ham processing. Are you using carrageenan to bind the ham together and if so, what are the effects of salt on carrageenan functionality?

*P. Shand:* I understand your question to be "How does carrageenan function in a ham system and what are the effects on salt?" Adding salt inhibits the hydration of carrageenan in the brine before you inject the product. Once the product is injected, the carrageenan is within the product. Upon heating, the carrageenan will solubilize; and then as the product cools, the carrageenan sets up the gel network.

*G. Schmidt:* I would add to that, if the carrageenan hydrates in the brine, you would then have a tank full of gel and this would be really difficult to pump. If you were to do this once, you would understand the reason.

*S. Godber:* One of the nutritional properties of meat is that it has an abundance of trace elements that are in a very bioavailable form. When we start putting these hydrocolloids in there, is it possible that we are going to reduce the nutritional value of the meat through this process? Should we be concerned about this?

*Shand:* Should we be concerned with soluble fibers binding the trace elements in meat? There has been some research that has looked at the effects of various polysaccharide gums. In general, they found that the trace minerals uptake was minor. It may depend upon the particular poly-

saccharide and we have to deal with this further, once more gums are incorporated into meat systems. I think in general, these gums do not bind a great deal of minerals.

*Godber:* With regard to the chitosan product, it is not currently approved for use in foods and that is one of the reasons I think that they're hesitant to approve this ingredient because of its tremendous ability to bind metal and possibly reduce their bioavailability.

*Shand:* That is true for chitosan, it can bind metals but that is probably the mechanism that it's working by to minimize warmed-over flavors. So there may be a trade-off.

*J. Keeton:* One of the problems you might run into when you make a low-fat product, let's say franks, perhaps is related to using a little bit more lean. Do you think you might run into a problem with too firm of a texture in making low-fat products? And do you think you would actually want to choose a gum that does not form quite as good of a gel?

*Schmidt:* What is the interaction between the removal of fat and texture? I think this is where a technologist earns his keep because you are trying to maximize texture or optimize texture by decreasing fat, adding added water and other substances to come up with a texture that the consumer likes, which may be very similar to the 30% fat product or slightly different. Some people may like a slightly firmer product. You notice now in the last 6 months or somewhat less, two of the major packers at least have come out with: Hormel with a 10% frank which is not very firm and Oscar

Mayer is out with a lite 20% fat-free product which is not significantly different in texture than the 30% fat product. So those are two major products that have been successful.

*Keeton:* That is my observation in trying to make low-fat franks with gums we used, such as carboxy methyl cellulose had some application because the other gums were too firm and you actually had to use a gum that was less full formed and a less firm gel. However, you have other problems with flavor and other things.

*Schmidt:* So you want the ability to hydrate but no rigidity.

*D. Huffman:* I would like to make a comment and then follow with a question. I think one of the things that the technology does introduce is that we must look at every specific system for each specific product rather than coming out with generalization. I have a question for you, Glenn. If we go back to products, where are we going to get the low-fat raw materials?

*Schmidt:* Excellent question. The poultry industry is a very good response. There is no doubt about the perceived value and the regulation says you can use 15% poultry as long as it is listed in the ingredient statement. Is that correct? So, that's one place and going from 30% to 20% fat probably doesn't raise the price of your ingredients tremendously. Going to 10% fat in the finished product probably has a very big effect. I'm rather intrigued by the technology that may be a first step (Ross Process) at low-temperature rendering. This process separates the fat from lean by warming and centrifuging and this may be a mechanism of increasing leanness of some raw materials without greatly increasing the cost.

*J. Claus:* I would like to add a comment on the cost-related issue of substituting water for fat. Even though the addition of water is helping out from a textural standpoint, it is not a major factor in off-setting the increased cost of the leaner raw material. When added water is substituted for fat, the formulation will require a higher percentage of leaner, considerably higher-priced raw materials.

*Huffman:* I submit, Jim, first that product expense is not the major factor. I think there is plenty of market. We heard comments this morning about product that can be sold for a higher price. I don't think expense is a problem. Take lean ground beef, for example. I don't think we have a problem. We have to do like the poultry industry has done, you look at the whole bird. It becomes lean by a lot of hand labor.

*Schmidt:* The point is, if you lose your market for the 30% fat product, then making it cheap is no longer important, if you can't sell it. So your point is well taken. Does any one want to comment on where we should be in the market place? Is there room for all types of products from 200% yield to 70% yield? Where should this market settle out? Is there room for all types of products?

*S. Richert:* I have had occasion to work in several markets around the world where we have quite different regulations. I think it's quite obvious where we have regulations that permit a lot of latitude in making meat products, you find products that pretty much cover the range. Where regulations constrain you to a small range, then those ranges are filled as well. If you have enough of a variety of what consumers want, they will accept all these different products if given the opportunity.

*Schmidt:* Where do you think our market in the U.S. will

peak out? Let's just say in the ham world, I think when the label restrictions were put on for ham and water product, many people thought that there would be nothing like that produced. There was some rather creative coloring of labels and there was a lot of product produced and sold with 150% yield. Is that continuing or are consumers getting upset with that product? Do they want 110% yield in ham, roast beef, and turkey products?

*Richert:* There are people moving quite rapidly towards that 200% market for hams. Another example of this is in beef patties because I'm aware of many beef patties that contain less than 50% beef, some as low as 30% beef which would give you 300% yield. That regulation is quite open. I'm not saying those products are the highest quality, but they do serve a need because they do sell. They have found a market and they do use up considerable quantities of fat beef because the only beef in them is 50/50 beef trim.

*M. Solomon:* I have a slightly different question with respect to the gums or some of these new technologies. They will influence the yield but will the final caloric content be influenced? What is the caloric content of the polysaccharide gums in your meat systems?

*Shand:* Because they are not digested, I don't think they would influence the caloric content. However, it's not well known what percent of the calories in a carrageenan for example are available. There has been limited research in animal models but it is not clear just how much of the gum is digested. So, I cannot say for sure how many calories but they are very low in calories, probably perhaps as high as 1 calorie instead of the usual 4 calories per gram of the other carbohydrates.

*Solomon:* If you are having a protein to protein or some sort of interaction, would it in turn have an effect on the cooked product rather than raw? I have not seen any information on that so the question is related to whether or not the profile of fat, protein, and carbohydrate is different in the cooked product compared to the raw.

*Shand:* It would definitely change in the cooked state. If you had some moisture losses and perhaps some fat losses by adding increased carbohydrates to these products, you would increase the proportion of calories from carbohydrates.

*Schmidt:* In addition, if your system is functioning properly and you don't have much cook loss, you don't lose any fat, you don't lose any carbohydrates. If the system fails, then the carrageenan comes out with the water and probably takes fat with it.

*D. Cornish:* In challenge to your comment, Glenn, where the consumer is looking for a lower fat product. The challenge and opportunity is not only lowering the fat but also the cholesterol. Is there anything currently being done that will help to reduce cholesterol either through dietary means or something in laboratory seen?

*Schmidt:* That is a very good comment. I happen to believe that controversy concerning cholesterol will decline. However, there are a number of people who are putting a lot of effort into CO<sub>2</sub> extraction of cholesterol. There is an Australian system of chopping the batter in a cold bowl and separating out solidifying cholesterol.

*Keeton:* Another possibility is the enzymatic reduction of cholesterol using cholesterol reductase from an extract of

alfalfa leaves. Cholesterol oxidase might be a possibility although there may be some inherent health problems. Phyllis, I have a question I would like to have you comment on. Do you know if these "fibers" bind cholesterol in the intestine?

*Shand:* I am not aware of their ability to do this at this time.

*Keeton:* They may.

*Kasaback:* What is the cholesterol-lowering ability of oat fiber and gums?

*Shand:* I don't think we know enough to comment on the cholesterol-removing ability of the gums. I would like to comment that these ingredients would be used at low levels of ½% or 1% in meat and this might be a lower level than you would use them for a medical response.

*Schmidt:* I would view the question, will the government ever intervene in these claims "No cholesterol," but it's in a 50% fat corn fritter? They are implying that there is no cholesterol label that is healthy. Is this something where we are going to see more and more regulations?

*R. Mandigo:* Let me follow Glenn's comment in talking to Judy Quick with labels and standards or wherever she may have migrated up the line now. It would appear the answer to his question is that it is coming under greater scrutiny all the time. These claims about no cholesterol yet with the fat level that is gigantic are in fact being looked at now. Whether that becomes action doesn't really have a danger with a time frame on it.

*Schmidt:* We are seeing that in bacon, more and more with claims of no sugar added. That to me is one of the funniest ones.

*Audience Participant:* In most of the studies in which you used oat bran and oat fiber, you really have to increase your consumption of those to get an effect. I suspect that the levels that we are using would be infinitesimally small as far as binding cholesterol.

*Schmidt:* If we are removing 20% to 30% of the fat from the lean, are we removing 20% to 30% of the cholesterol? Is fat higher in cholesterol than lean?

*Audience Responses:* Yes . . . no . . . yes . . . no.

*R. Merkel:* There is a lot more membrane in the lean tissue than in adipose tissue.

*J. Savell:* That is correct but there is more storage cholesterol in the adipose tissue, compared to in the lean. In raw tissue, you will find twice as much cholesterol in the adipose tissues than in lean on a gram/gram basis. When you cook, of course you cook out cholesterol in the lipid which may reduce it somewhat, cook out moisture in the lean which causes the cholesterol to go up on a grams basis. It still ends up that you have 70mg of cholesterol in the lean vs. 90-100 mg cholesterol in adipose tissue.

*R. Field:* I would like to hear more, can you explain why veal has such a high level of cholesterol.

*Savell:* Our thought on veal is that there is much more membrane in a 100g portion or the muscle fibers are smaller. So, if 80% of the cholesterol in lean, at least in beef muscle tissue, is associated with the membranes, the chances that there are a whole lot more membranes associated with smaller muscle fiber in veal. So if veal changes to beef, you have a dilution. Then as muscle fibers grow, you have less membrane per 100g basis but you also have more lipids. So I think you have it down to a muscle fiber basis per se.

*Field:* You can't separate the two.

*Savell:* And that's the challenge you have at looking at veal versus beef.

*Field:* I think that is why we have this debate on what has the most cholesterol because there are many different tissues and different fiber diameters. I'm not sure that a flat statement can be made.

*Solomon:* We have evidence that indicates that muscle fibers don't necessarily influence it the way you suggested. Basically, we had some animals at Beltsville that were 100kg live weight, the percent fat in the carcass was 22%, yet for lean tissue from the same animals compared to controls that had 30% total carcass body fat, there was the same level of cholesterol. Yet the muscle fibers were larger in the 22% fat carcass.

*K. Rhee:* Early in 1981-82, there was a paper in the *Journal of Food Science* on the effect of marbling on cholesterol content. This is different when you consider comparing the cholesterol content of lean tissue to fat (adipose tissue). When you look at the lean tissue, usually the moisture content is around 70%. In the adipose tissue, the moisture content is around 20% depending on whether it is subcutaneous fat or seam fat. On a moisture-free basis or dry-weight basis, the lean contains a lot more cholesterol than fat. The opposite is true on a wet-weight basis which relates to serving size. If you think about moisture differences in lean versus fat tissue, it is all explained. I am not comparing veal versus beef.

*Schmidt:* On labels, it would be on a wet-weight basis.

*Rhee:* There was an editorial a while ago that reported that lean contains more cholesterol than fat. When you read this paper, it was on a dry-weight basis. But dietitians and product development don't eat dried meat.

*D. Naumann:* Phyllis, you implied there were flavor considerations that need to be looked into further. Is this a dilution of flavor or antagonist flavor of the addition of the gums?

*Shand:* I don't think it is known yet whether or not the gums lead to a dilution of flavor or antagonist flavor. I think some gums might make more of a difference than others. In the poultry industry, they found that the carrageenans don't have much of an effect on flavor.

*Schmidt:* In the products that we made where we add carbohydrates (starches and gums), we tended to bind up water and that bound up water-soluble flavors. Does any one disagree with that statement? We got a depression in the meaty flavor. We did some restructured meats and if you lose beef flavor, you don't like that. But if you lose lamb flavor, that is sometimes thought of as an improvement.

*Field:* Wasserman wrote and it has been in the book ever since, "the species difference is in the fat" and other people have repeated that. I think there is a real good reason to question that today and a real good reason to do more work on flavor. When we talk about products like this, we are certainly going to have to understand beef or lamb flavor better. Our preliminary work certainly indicates that we can trap beef flavor or lamb flavor in water.

*R. Hawkins:* First of all, I disagree with Dr. Rhee, we do eat dry meat and if we didn't, I would be out of a job. At Good Mark we produce beef jerky and other dried products. Are we ready in the red meat industry to reduce some of the regulations that we have and make them more in line with the

poultry industry so that we can untie our hands to manufacture lite meat products that taste good?

*Schmidt:* Why do we have separate regulations for red meat vs poultry? Does any one have any other reason other than final cook temperature, why anything should be different?

*Field:* I can't resist a comment on that. I have asked the question for 20 years as it relates to mechanically-separated meats.

*Audience Participant:* When we are dealing with our consumers, I don't mind putting something in the ingredient statement as long as I don't have to put it as a qualifying statement on the main label.

*V. Cahill:* I think you made a very significant statement in that flavor doesn't really matter to the consumer. What does that signify for the future of the meat industry?

*Schmidt:* I make a statement to our undergraduate students when I teach a meats class that we have now created several generations of white meat franchised consumers. They understand the Golden Arches or if it is not a hamburger patty or a skinless frank, they really don't want to eat it. If they can recognize it and it is slightly offensive, they no longer want to eat it. So franchised foods have become the gourmet food of today, like the speaker said this morning, "Velveeta is in the gourmet cheese case." That is the way a lot of this country is being raised with very unsophisticated tastes. As we take fat out of food you lose satiety. Will people simply eat the same number of calories from other sources to make up for that reduced fat intake?

*Hawkins:* I think where they will go is in the snack category. We found that with our consumers who we deal with and that's with snack products, they think that these have no calories, this is between meals and this does not count. They watch their calories other times.

*Schmidt:* I think there is little reason to believe that consumers eat low-calorie foods and then don't eat what they want anyway.

*Richert:* I predict that if the meat industry is allowed by regulations, it would go like the dairy industry has gone with fat levels and that can be seen in beverage milk and ice cream. In fact, ice cream and frozen desserts, what you see today are gourmet products, very high quality ice creams and very popular. At the same time, we have very low-fat frozen dessert, not real ice creams, which are very popular. And then you have new product categories such as frozen yogurts that have really taken off. That is how the regulations seem to permit those kinds of products. I think if the meat industry can get creative and develop products that are high quality and new categories like the frozen yogurts, they will still have the opportunity to make very good quality products like the gourmet ice creams.

*M. Hunt:* Glenn, how do you define quality in a low-fat product? We talk about high quality, low quality, no additives, lots of additives, low water, high water, good texture, firmness, color, beef flavor, meat flavor, no flavor.

*Schmidt:* Quality is based on the price that the consumer is willing to pay repeatedly. Some people would say lite beer is a terrible product, some people say that it is wonderful. If the customer is willing to pay a premium for that product repeatedly, it is high quality. Also, what is perceived as quality may change with time.

*Field:* Your definition makes ground beef a high-quality product compared to prime beef. Then ground beef is the highest-quality meat product we have.

*Schmidt:* This is because of many repeat purchases. Given the choice, if we had a room full of average citizens and had them in 30 main meals a month, check how many times they would like to eat the following products, I think ground beef would come out a winner. And that's high quality.

*Claus:* I would like to add to the definition of quality. It is important within the definition of quality to state that product consistency or consistency of producing the product also reflects a degree of quality. So there are sensory attributes and manufacturing controls that relate to the quality of the product.

*Schmidt:* To me, the repeat purchase is the major, major item of quality.

*Audience Participant:* This question relates to how high we can go in yield related to products. Some of the stores now are doing very good at labeling the ham and water products. Labeling that product in big bold letters and there is 80 to 90 cents a pound difference between the ham and the ham slurry, as one of the county agents put it. People buy it and they are very happy with it and they continue to buy it.

*Schmidt:* What would make consumers very unhappy with that product?

*Audience Participant:* If it didn't taste good.

*Schmidt:* If they put it in the microwave and 50% of the weight comes out.

*Audience Participant:* Only if they saw it come out; if you put it in the oven and cooked it according to instructions, when it comes out you won't really notice the weight loss.

*Schmidt:* In a microwave, you will definitely notice the weight loss.

*Audience Participant:* The consumers do not really care about the yield of the product.

*A. Kotula:* There is one other thing that is going to make them upset and that is if a consumer group comes out in the press and says that you are being ripped off. There is one consumer group that has targeted the poultry industry for the water that is added to poultry. So I think before the meat industry jumps on, they are going to have to watch what's happening to the poultry industry; because if you get bad press, that can have a very negative effect on your business.

*Schmidt:* How do you justify diet soft drinks and lite beer?

*Kotula:* It all depends on who they target.

*Schmidt:* But it's the perception of the product.

*Kotula:* That's it. That's exactly it. And if you get the correct consumer groups targeting meat that has some added water, then you have to be very cautious.

*Cahill:* When we talk about quality, you can't compare apples and oranges. We need to restrain ourselves to categories: for instance, one can't compare ground beef quality characteristics to those of frankfurters because they are two different products. So we need to stay within a given category.

*Schmidt:* Let's take pre-cooked roast beef. Is a no water-added, 80% yield roast beef, 110%, 130%, or 150% yield, the best product or the highest-quality product?

*Audience Participant:* By your definition, the one with the largest volume.

*R. Miller:* I used to be in that business before I went to

A&M. What's different about roast beef is it's changing, and the 85% yield cook product 7 years ago was perceived as the product that you were to target in the market because people didn't want to eat the type of product that had the texture of a ham or the texture of poultry products. But then what happened is that the fat was removed and the price was increased so that in the quality equation, price does come into play. Unless you are close to the 100% yield, you are really not going to be the volume producer. It's slowly changing in that value perception is different. The consumer tests that we did with roast beef, where we didn't know what the consumer wanted, we had to try and find out. They preferred the product that was higher yielding that we didn't consider was acceptable in flavor and they bought \$4.99/lb roast beef at the deli that I thought would never sell.

*Schmidt:* That's the problem with using meat people to determine how the product is going to perform in the market place.

*C. Griffin:* How does the flavoring rule affect labeling of maltodextrin?

*Shand:* Maltodextrins, I believe, cannot be added to products with standards of identity. However, they are allowed in other products.

*P. Graham:* I wonder if you have had any experience in using any of these in combination?

*Shand:* No, we haven't but there has been a few people that have. Foegeding looked at low-fat meat batters using carrageenan in combination with locust bean gum. He did not see a synergistic effect that was reported in aqueous systems. However, that is an area that should be looked at further. For example, what happens with carrageenan and milk proteins? I know they have synergistic interaction but I am not sure if that occurs in the meat products.

*Schmidt:* Paul, that's a very good question, but as you can see, Phyllis has looked at 10 different gums in this project and if you start doing combinations and levels by species and added water, this could be a long Ph.D.

*M. Mann:* My question is related to consumer perceptions. My particular division makes standard of identity sausage products. We by law can't use these in our products and call them what we call them. If we make the products using this which gives us (a) a better yield or (b) "better health claims" for our consumers, in your dealings with the industry or your own marketing research, does a consumer perceive the health benefits as greater than the standard of identity or vice versa? If you call it a hot dog, I know what I am getting regardless of the fat claim. If you call it a round link at 99% fat-free, I don't know what that is but maybe I am drawn to the fat-free claim.

*Schmidt:* That's a very good question. Can we think of an example where some food has given us a standard of identity and been successful? I think of ham and water product that I personally felt that nobody could make successful because of the name, and yet there's a lot of it being sold. Apparently the consumer has perceived the cost savings to be enough to overrule the negative labeling. Perhaps somebody else has another example where the name has changed but the markets have actually increased. Lite beer is an example I would like to use. That's a negative. It's not real beer — it's lite beer. Does it sound better or worse than the real thing? It has found a niche market which is willing to pay at least an

equal price and even a premium.

*Shand:* As another example, in the dairy industry where you don't have ice cream, now you have frozen desserts which are not ice cream but are still doing real well.

*J. Carpenter:* I have a two-part question. What is the lowest fat level that you have achieved in a satisfactory frankfurter? What did you substitute in there for the fat?

*Schmidt:* We haven't worked with frankfurters but if you look at what is out on the market: Oscar Mayer is out with a 20% fat product; Hormel is out with a 10% fat frank. A 10% fat product as far as someone who knows something about meat products is marginally acceptable. The 20% fat product is probably better than the 30% fat product. Now those are my opinions. Does anyone have a different opinion? Because all this is, is an opinion, whether you think it's good or not.

*Carpenter:* It is possible to make an 18% fat frankfurter out of all mechanically deboned chicken and you don't have to add anything. And as far as the raw material cost, it will only cost about 18 cents per pound. My point is, you spent time talking about the hydrocolloids and the substitutions and I was trying to get you down to the nuts and bolts of how much of what kind do you have to put in when you take out fat? And how much does it take to hold the water in whatever product that you are making.

*Schmidt:* I think there are many different combinations that can hold the water. You can have a very attractive product but how good it will taste, we don't know. We are not at that level of sophistication at this point. Jim Keeton was in the last group and he has done some work in this particular area. Does anyone in the audience here have anything to add to this subject? How low can you reduce the fat in a cooked sausage and still make an acceptable product?

*Claus:* I'd like to comment on that. One of the projects that I was involved in, we looked at characterizing bologna type products with different fat and added water combinations to meet the USDA requirement that stipulates their total can not be more than 40% with the fat not exceeding 30% as traditionally specified. When substituting an appropriate level of added water for fat, an acceptable product can be made from a firmness standpoint but then you potentially create some other problems as you indicated when you change the system. Two of the problems are: first, you increase the amount of purge accumulation in the package during storage and then secondly, you have an affect on the flavor profile by removing some of the fat and replacing it with water.

*Audience Participant:* In your presentation, I haven't heard anything concerning sodium lactate in low-fat meat products. What information do you have on this particular topic and the flavor enhancement of sodium lactate?

*Schmidt:* We haven't looked at the affect of sodium lactate on flavor at all. However, there seems to be a linear effect of the addition of sodium lactate on the shelf-life of the product. It is an antimicrobial ingredient and that will help shelf-life. How it affects flavor, we don't know.

*J. Acton:* Related to sodium lactate, you said that you get extended shelf-life and I'm assuming that's microbiologically. Is that in a cooked or fresh product? If it is in a fresh product, is microbiological the number one reason for using it? Or what about the color problem, that's really what I'm getting at? Do you have to be careful about sodium lactate or are you

advocating it relative to use in a fresh system or a process system?

*Shand:* I'm aware of some of the work by Texas A&M where they looked at a cooked roast beef system including sodium lactate. In that product, the lactate contributed to the longer shelf-life from a microbial standpoint and also helped with flavor. One of the problems was when they got high levels of lactate.

*J. Lamkey:* With fresh pork sausage, we found that the color was maintained throughout a 40-day storage. The microbial growth did increase at the end of 35 days but the color was maintained, and that's under a non-impermeable package. In a fresh retail case condition, we saw that color might deteriorate more rapidly.

*D. Zimmer:* What's the effect of sodium lactate counteracting the effects of antioxidants? I'm aware of the relationship between pH in fresh pork sausage or fresh ground pork. As you decrease the pH from 6 and below you see a rapid increase in a rate of oxidation. Have others looked at the effects of oxidation rate with the incorporation of lactate?

*Schmidt:* Sodium lactate doesn't affect the drop in pH in the meat system. Is that correct?

*Lamkey:* No, it doesn't. We found no change in pH and we used two different pH's of sodium lactate. One was 6.5 and the other was 7.0.

*Schmidt:* It is an interesting compound from the fact that it has a color effect, a microbial effect, and a flavor effect and it's a nice innocuous-sounding compound.

*Acton:* These hydrocolloid materials are in their infancy in utilization in meat products. It reminds me of the first testing of phosphate. It's like unraveling a puzzle. There's a lot of carbohydrate chemistry involved because most of them are produced naturally. Therefore, we only have rough fractionation for a lot of them. My question is: Until you get to studying interactions between these components, we won't really know how they behave under different types of systems because a boneless ham product is tremendously different from a comminuted product or even a mechanically deboned product in the case of a chicken frankfurter. It's a very complicated set. I wonder if you have given any thought to the interaction? A secondary problem is what does it do to the microbiological status of that product relative to the fact that these are fairly high molecular weight polymers?

*Shand:* As you indicated, we are just beginning to look at some of these hydrocolloids and have not yet looked at any of the interactions. In terms of microbial stability, it has been looked at in the alginate system and the stability has been found to be not different from that of an all-meat product or a restructured meat product made without any addition. However, this has not been looked at extensively in terms of other polysaccharide gums. They are generally non-digestible. They are not broken down by very many species of microorganisms and so probably will not support microbial growth to any large extent.

*Mann:* Of the data that you have shown us today, did you by any chance determine the water activity measures of the different products that you made and if so, what were the differences you saw?

*Shand:* No, we did not take water activities.

*Mann:* Would you care to predict what they would be?

*Shand:* These products do contain a high water content.

The moisture of some of these ingredients is 75-76%. I do not know the effects of water activity and in addition, the gums were added at a level of 1% or less.

*Mann:* I ask because some of the work that we've done in reducing fat; if you increase the water activity, you have a linear relationship with shelf-life which is usually downward. And the work that we're trying to figure out is: What can you put in there along with the water to keep the water activity at a constant level and equivalent to a 30% fat product and maintain a constant shelf-life?

*Schmidt:* That question and that complexity of a problem brings up the question of the problem of what Jim Acton asked. This brings out the philosophical question: How do you approach the search? Do you study something and look at the interactions of galactose and a peptide or do you try everything under the sun at all levels to define the universe that works and then work out the details? Which is the better approach? I think that's why we have a room full of people because there needs to be several approaches and as Jim said, when we started to study phosphates and it became available in cooked sausage, there were plenty of people who said that we will never use it because of the concern of putting it on the label.

*Carpenter:* Let's see if I can get this discussion straight. Are we talking about lower fat or higher water content sausage? Which are we trying to sell? Are we looking at mechanisms to bind the water?

*Schmidt:* That brings up the question of quality. Which is the higher-quality product? Let's take an example of some products that are on the market, for instance roast beef. Is a dry cooked product with 75% yield, one with 100% yield, 110, 130, 150 and 200 yield, the highest quality product? Is the 75% product the highest quality because we are selling the least amount of water? Someone indicated the one that most accurately meets the consumers' needs. Which one is that? The same response was given during the last session. Which one will be the one that people will buy, looking at roast beef? Probably 110% to 150%, above that we start getting gelatin, gelatin dessert and below that it's tough, dry, and expensive. Somewhere there is the perceived value (and that's the key word); we are not trying to sell all the water in the world. That's the point we are trying to make. Perrier does that.

*B. Kenney:* Should we be satisfied with perhaps the fact that we can't sufficiently alter pH, protein solubility, ionic strength, and muscle protein solubility profile. Therefore we must look to some of these other ingredients to fill in the gap or should we be looking at altering muscle protein physicochemical properties to take up some of the slack? Is that a feasible approach in your mind? Is this the way to go?

*Schmidt:* In other words, should structure complement meat or from somewhere else? It is possible to make a sausage with no meat or very little meat. It will have a texture that is different than one based on meat protein matrix. I think based on current information, even related to the younger generation, meat texture is still of some importance. We want to maximize the amount of texture that we get with a certain amount of meat and I don't think that we are quite ready for a pink tube of something that contains a minimum amount of meat.

*Kenny:* So just some meat though?

*Schmidt:* No, I think there is a value in quite a bit in the

optimal product. The one that has the largest market. The texture will still come from meat and the meat protein matrix. There are products currently on the market right now that contain 30% of 50/50 trimming and the rest of the product is something else. That's for a specialty, very low-price market.

*Johnson:* We have centered our discussion around sausage products; but because of the consumption of ground beef being so high in its contribution of fat to diet, I am just wondering why we are not seeing more impetus in the industry side, speaking specifically of the fast-food industry, to really introduce low-fat hamburger. Why do you think we haven't seen a push or pull to do that in our industry?

*Schmidt:* I think the sign on the door that says "We use 100% American ground beef," limits a lot of things because as you get lower in fat, the price goes up. They may say that they want a low-fat product, but you notice now, especially Wendy's is advertising, "Don't eat this nouveau cuisine, that nobody can get full on, come in and get a Dave's special with two patties and 3 slices of bacon." So that market is probably not ready for reduced calories in the hamburger. Even though they'll offer a salad bar with low calories. Does anyone see this trend in the industry? Some of the people have had it with the low-calorie items and they really want something real to eat. McDonald's is playing on that a bit.

*B. Reiling:* We're doing a lot of research with utilization of bulls for fast-food restaurants. We had a meeting with the president of one of the fast food-restaurants, or merchandisers, and the attitude that we got was that they are extremely health conscious in wanting to put forth a low-calorie product. They are really pushing the salads and those type of things but they feel that they also want to go forth with a low-calorie hamburger of some sort. They really feel that the health-conscious consumer is out there and that is the market they want to try and reach in the next decade. They want a real low-fat, low-cholesterol type product that will maintain the quality. I think that is the general trend that they want to reach.

*Schmidt:* What is our current low-cost, low-fat ground beef?

*Reiling:* Right now they are using 90% cow meat.

*Schmidt:* Are there any alternatives available?

*Reiling:* What they are looking at is utilizing bull meat.

*Schmidt:* Is bull meat cheaper than cow meat?

*Reiling:* I think what they also feel is that if they can get a product that the consumer perceives as a very health-conscious product, that the consumer may be willing to pay an additional 10, 25 cents or whatever it takes to make up the cost.

*Schmidt:* It sounds like meat scientists need to develop very fast-growing lean animals that don't eat very much.

*Carpenter:* If you are talking about ground beef, you are talking about a product that has very narrow limitations. And as far as flexibility with adding fat and adding water, if you reduce the fat too much and of course, it gets too tough and you can't go too high with the fat. So you have some narrow limitations there. If you try to substitute something in there, that puts you out of the all-beef market. And that puts you out of the fast-food market. So what the people have expressed here is probably desirable, but I don't know if it's attainable and still call it 100% beef. You've got a lot more options in the products that you mentioned, the cooked roast beef, and the ham and water product, even more so in the emulsified products, the sausage, frankfurters and smoked sausage market.

*Schmidt:* However, we do consume about 4 billion pounds of ground beef. So, if someone could figure out how to have an all-beef, lean product that tasted good and has the proper texture, that would be very valuable. There are many markets out there. There are many options for meeting these markets. Some of the research is well established and is being applied. There are new areas opening up and there are a lot of young people in the room. It's good to see that you have plenty to do.