Impact of Fat Reduction on Palatability and Consumer Acceptance of Processed Meat

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Introduction

Fat reduction in processed meats is an important topic in view of consumer interest in reducing caloric intake. The development of 90% and 95% fat-free meat products 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 processed meat items. Thus, the question is not whether consumers want low-fat meat products, but how can they be produced and still be palatable?

In order to set the stage for this topic, we will first review the classification, structure and localization of lipids in animal tissues. We will then briefly review the roles of the different lipid components in nutrition and health. Then the functions and amount of the different lipid components needed for optimum palatability in processed meats, including ground beef, will be reviewed and we will consider both their advantages and disadvantages. Finally, procedures for achieving acceptable low-fat processed meat products will be considered.

Classification, Structure and Localization of Lipids

Lipids can be classified into: (1) esters of glycerol and fatty acids in which each of the three alcohol (OH) groups of the glycerol moiety are esterified with a fatty acid to form triacylglycerols (triglycerides); (2) esters of long chain fatty alcohols, which are not generally present in appreciable amounts in animal fats; (3) esters of glycerophosphoric acid coupled with a nitrogen base and/or carbohydrate, which are called phosphoglycerides or phospholipids; (4) derivatives of the long-chain hydroxyamino alcohols that are commonly called sphingolipids; and (5) steroids and related compounds that are localized in the non-saponifiable fraction, one of the most important being cholesterol.

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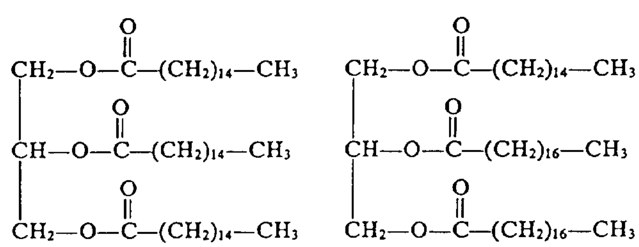
Triacylglycerols

The triacylglycerols are the most abundant lipid components in nearly all meat products and are commonly referred to as neutral fats. The structure of a triacylglycerol is shown in Fig. 1. Their stability is closely related to the degree of unsaturation of their fatty acid components. Triacylglycerols are the major components of adipose tissue and exist in five major depots: (1) subcutaneous fat, (2) intermuscular fat, (3) intramuscular or marbling fat, (4) kidney or perirenal fat, and (5) other lining fats located on the interior surface of the carcass. Additional fat is also located around the intestines, rumen or stomach and other organs. The latter type of fat is generally removed during slaughtering along with the viscera and is not a major contributor to meat fat per se. Subcutaneous fat can be easily removed during cutting and/or processing. Recently, there has been an increased emphasis in removing or reducing the amount of subcutaneous fat to no more than ¼ to ⅓ inch on retail meat cuts, thus taking advantage of its easily accessible location to reduce fat content. It is also relatively easy, although not cheap, to reduce the fat content by removing the perirenal fat and some of the interior fat which some packers are now routinely

Figure 1



Simple triacylglycerol (tripalmitin) — Mixed triacylglycerol (1-palmitodistearin)

Structure of a simple triacylglycerol (left) in which the three positions on the glycerol molecule are esterified with palmitic (C16:0) acids. Right: A mixed triacylglycerol in which one of the hydroxyl groups of the glycerol is esterified with palmitic acid (C16:0) and the other two with stearic acid (C18:0).

removing during the dressing operation. There are distinct advantages in removal of fats by packers since much of it can be utilized as edible fat or rendered to produce edible tallow, whereas at the supermarket level much of it is only useful as inedible grease.

Removal of intermuscular fat from the rear quarter is relatively simple, but it is extremely difficult in the forequarter. Thus, it is nearly impossible to prepare low-fat products from the chuck, shoulder or picnic, which would be of the lowest cost.

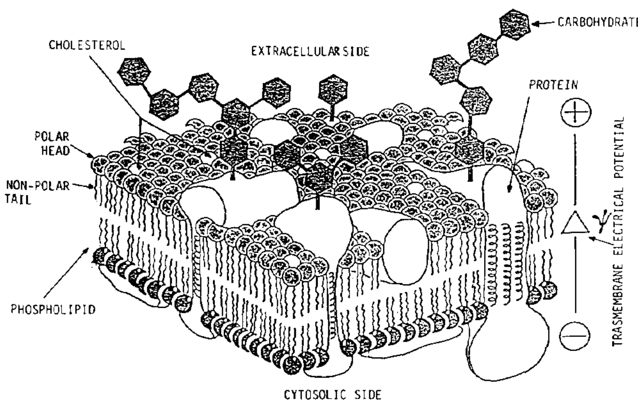
Intramuscular fat cannot be removed, with a goodly portion of the analyzed fat being located in the membranes. The structural contribution of lipids to the membranes also leads to their oxidation during grinding, flaking and even cooking. Thus, the intimate association of the lipids in the structure of the membranes imposes a serious stability problem during processing and/or cooking. However, the triacylglycerols are the easiest of the lipid components to remove, and are probably the most stable during processing.

Phosphoglycerides

The structural formulas of two phosphoglycerides, namely, phosphatidyl ethanolamine and phosphatidyl choline, are presented in Fig. 2. The phosphoglycerides are structural constituents of the membranes and their stability is closely associated with the degree of unsaturation of their constituent fatty acids, which tend to have a relatively high degree of unsaturation. In general, phosphatidyl ethanolamine is usually less stable than phosphatidyl choline due to a greater amount of unsaturation of its constituent fatty acids.

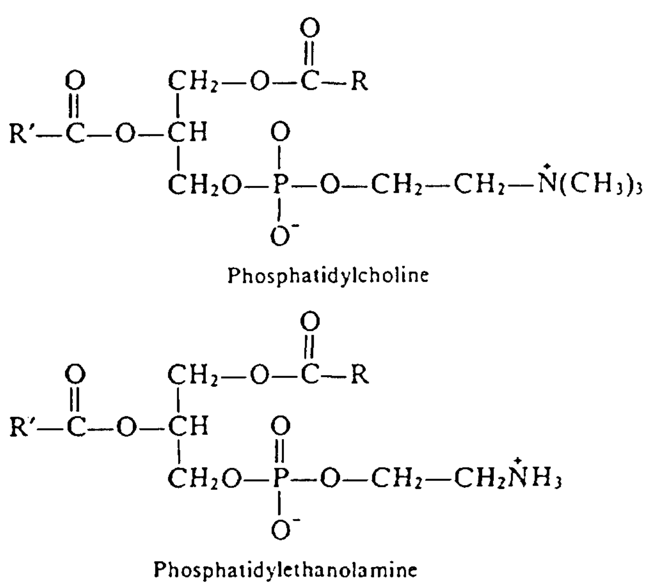
Breakdown of the membranes by flaking, grinding, cooking or other mechanical means exposes the membrane components (Fig. 3) to oxygen and contributes to their susceptibility to oxidation. The fatty acid moieties in the membranes also influence their stability. Recent research has shown that diet can alter the fatty acid composition of the phosphoglycerides, with the degree of unsaturation being closely related to the diet for marmoset monkeys (McMurchie et al., 1986) and chickens (Asghar et al., 1987). The stability of the phosphoglycerides of the membranes is also influenced by inclusion of antioxidants in the diet. The effect of diet on the fatty acid composition of the membranes in the chicken is shown in Table 1.

Figure 3



Schematic Diagram Depicting the Bilayer Organization of a Eukaryotic Plasma Membrane (Modified from Cullis and Hope, 1985)

Figure 2



Structural formulas for phosphatidyl ethanolamine (bottom) and phosphatidyl choline (top). The greater amount of unsaturation in the fatty acid substituent of phosphatidyl ethanolamine makes it more susceptible to oxidation.

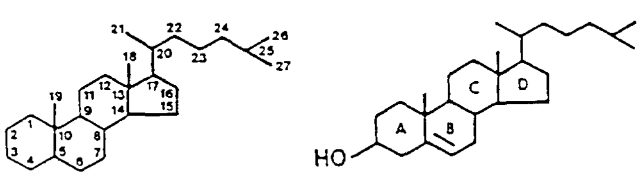
It is doubtful if the composition of the phosphoglycerides in the membranes of ruminants can be altered by conventional methods, since the rumen microorganisms tend to have an over-riding effect on composition (Pearson et al., 1977). It is, however, possible to modify composition of the tissue lipids of ruminants through by-passing the rumen (Scott et al., 1971; Cook et al., 1972; Ellis et al., 1974), which can be accomplished by feeding protein encapsulated fats. Shorland et al. (1981) were able to alter the composition of the lipids deposited in the tissues of veal calves by feeding a liquid ration so that the rumen was by-passed through the esophageal groove.

Table 1. Effect of Dietary Fats on Phospholipids in Microsomal Fraction from Dark Chicken (Leg) Muscle[a].

	Fatty Acid Content (%)	
Dietary Source of Fat	*Coconut Oil*	*Linseed Oil*
Class of Fatty Acids		
Saturated	36.7	24.9
Monoenes	25.5	22.8
Dienes	18.8	22.6
Trienenes	3.7	4.8
Tetraenes	11.3	5.2
Pentaenes	1.3	3.9
Hexaenes	0.1	5.5

[a]Taken from Asghar et al. (1987).

Figure 4



Structural formula for cholesterol showing the carbon numbers and the position of the double bond in the B-ring.

Sphingolipids

There are only small quantities of sphingolipids in muscle, and they are associated with the nerve tissues. Little is known about the composition of the sphingolipids associated with muscle and the factors that influence their composition and stability.

Cholesterol

Although there are a number of components in the nonsaponifiable lipid fraction, cholesterol is the most important, both quantitatively and physiologically, so will be the only component discussed. Cholesterol is essential to body processes serving as the parent compound for synthesis of the steroid hormones, including the androgens, estrogens and corticosteroids. Cholesterol also serves as a structural component of the cell membranes, where it helps to maintain fluidity and functions in passage of nutrients and waste products of metabolism through the cell membranes. Fig. 3 presents a model of a cell membrane.

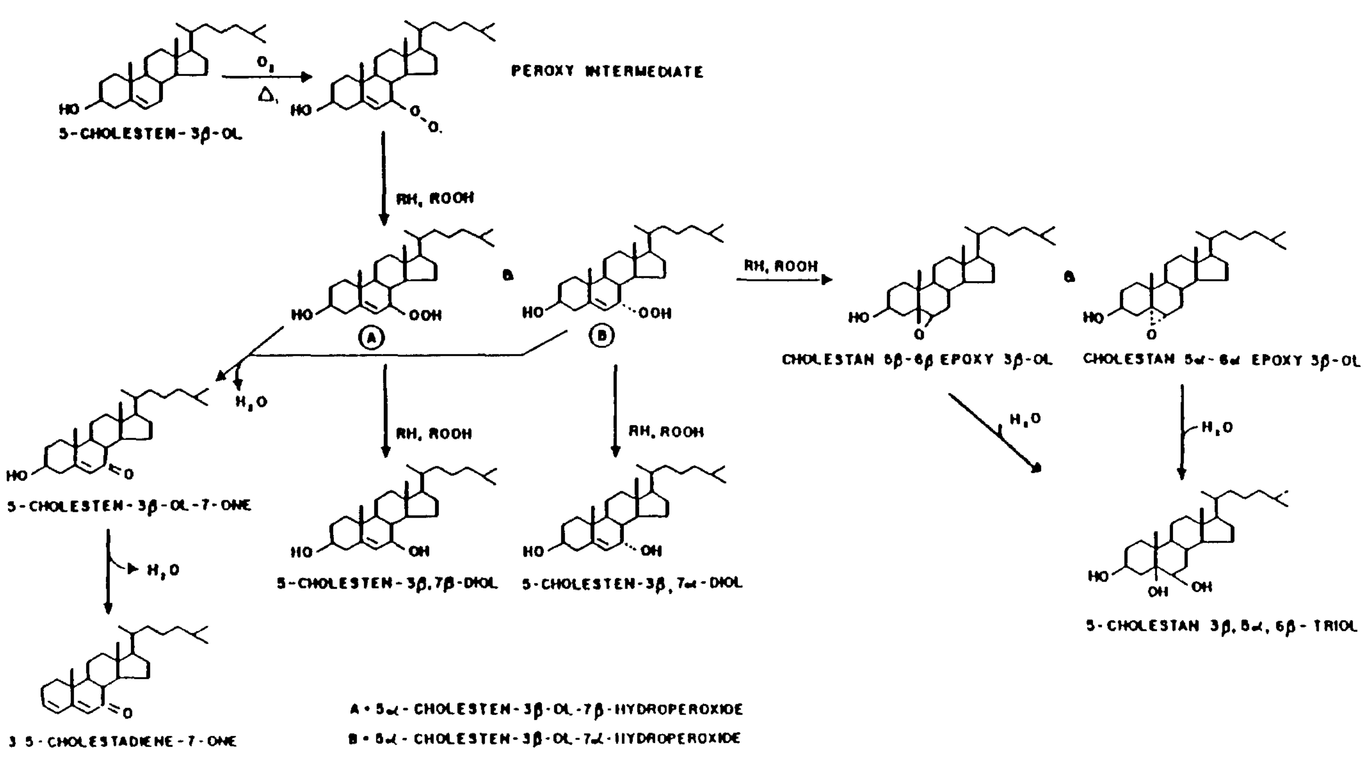
Fig. 4 shows the structural formula of cholesterol, which can also be oxidized to form the various oxidation products shown in Fig. 5. However, the susceptibility to oxidation is limited by its structure, where oxidation first occurs at the double bond between carbons 5 and 6 in the B-ring.

Table 2 presents data on the total sterol content in organs and tissues of the rat. The percentage that is esterified and the percentage of non-cholesterol and cholesterol content is also given. The amount of cholesterol varies from a low of 1mg/100g for the adrenal glands up to 93 mg/100g for nervous tissue, including the brain.

It should be noted that the cholesterol content of adipose tissue is much lower (16 mg/100g) than that of muscle (76 mg/100g). Although the data given are for the rat, the value for muscle falls within the range reported for beef muscle. Thus, it is evident that substitution of lean with fat would actually tend to result in a decrease in the cholesterol content. This concept was first proposed by Reiser (1975) with the supporting data being given in Table 3. Further support for this view is found in the data shown in Table 4, which shows that raw ground beef contains 66 mg/100g, at a fat content of 15% (Breidenstein, 1987), whereas raw ground veal with a fat content of 1.5% contains 93 to 104 mg of cholesterol per 100g (Ono et al., 1986). This illustrates that low-fat meat may actually contain more cholesterol than meat that is fatter. Support for this viewpoint can also be found by data taken from Rhee and Smith (1983). On the other hand, fat may slightly increase the cholesterol content (Table 4), as shown by Kregel et al. (1986).

Rhee et al. (1982b) had shown earlier that cooking concentrates the amount of cholesterol, even though some cholesterol is lost in the drippings. The cholesterol content after cooking (wet basis) fell in a range of 105 to 113 mg/100g for beef.

Figure 5



The steps involved in oxidation of cholesterol and the various oxidized products.

Table 2. Sterol Content of Organs and Tissues of Rat[a].

	Total Sterols			
Organ/Tissue	Fresh Tissue mg/100g	Esterified %	Non-cholesterol %	Cholesterol mg/100g
Plasma	80	76	1	7
Small intestine	195	5	4	18
Liver	246	30	2	42
Kidney	336	1	2	11
Adrenal Gland	3,445	75	3	1
Skin	196	52	64	68
Hair	1,125	67	68	46
Adipose tissue	59	8	2	16
Skeletal muscle	65	3	15	76
Bone marrow	274	4	2	22
Red blood cells	145	<1	<1	10
Nerve tissue	1500-4000	<1	3-10	93

[a]Taken from Gibbons et al. (1982).

Table 3. Relation of Fat to the Cholesterol Content of Meat[a].

	Fat	H_2O	Cholesterol/100g Fresh	Cholesterol/100g Dry	Cholesterol/100 kcal
	%	%	mg	mg	mg
Chicken					
Drumstick	3.9	77	91	388	61
Adipose tissue	75	15	65	77	9.0
Lamb					
Lean	6.8	72	70	250	49
Adipose tissue	73	19	75	93	11
Beef					
Lean	7.4	70	65	218	41
Adipose tissue	76	17	75	90	10.5
Pork					
Lean	10	69	60	194	35
Adipose tissue	81	13	70	81	9

[a]Taken from Reiser (1975).

Table 4. The Effect of Degree of Fatness on the Cholesterol Content of Meat.

	Fat Content (%)	Cholesterol Content mg/100g
Beef-raw[a]	15	66
Veal-raw-bob[b]	1.5-1.7	93-104
Veal-specially fed[b]	1.8-4.3	71-88
Ground beef[c]	8.0	66.8
Ground beef[c]	16.0	64.5
Ground beef[c]	27.0	58.1
Ground beef[d]	8.7	51.3
Ground beef[d]	27.8	59.7

[a]Breidenstein (1987).
[b]Ono et al. (1986).
[c]Rhee and Smith (1983).
[d]Kregel et al. (1986).

Role of Lipid Components of Meat in Nutrition and Health

The primary consideration in this discussion will be the need for dietary lipids and the problem of certain lipids in the diet.

Essential Fatty Acids

Lipids are essential nutrients with the body having a requirement for essential fatty acids, namely linoleic, linolenic and arachidonic acids. Although all three of these fatty acids are considered to be essential, i.e., they are required preformed in the diet. If adequate quantities of linoleic acid are present, the body can synthesize linolenic and arachidonic acids (Loosli and Maynard, 1969). The essential fatty acids serve as precursors for the prostaglandins and are essential components of all cell membranes, as was pointed out earlier. On western-world diets, it is uncommon to find any fatty acid deficiencies unless some pathological condition also exists. Thus, most Americans do not suffer from fatty acid deficiencies, but rather from an excess of lipid with its attendant problems.

Disadvantages of Lipids from Meat in the Diet

The criticisms of lipids from meat in the diet stem from three issues: (1) cholesterol, (2) saturated fatty acids, and (3) calories. These points will each be briefly discussed.

Cholesterol

Cholesterol is deposited in the arteries to form deposits or plaques, which restrict blood flow and are related to coronary artery disease. Although a number of factors are known to be associated with plaque formation, including smoking, heredity and diet, the effects of diet have largely centered on the cholesterol content of foods, mainly eggs and meat and its absence from plant products.

There is a definite relationship between plaque formation and the number of deaths from coronary heart disease (CHD). The fatty streak of atherosclerotic lesions is composed almost entirely of cholesterol (Sabine, 1977). Thus, there is little doubt about the involvement of cholesterol in CHD, but the mechanism(s) regulating cholesterol concentrations in the blood and its relationship to dietary cholesterol is more controversial. The American Heart Association has recently gone on record as recommending that dietary cholesterol be limited to 150 mg per 1,000 calories. Such a diet would virtually eliminate eggs and meat from the diet, even eggs for cooking.

The relationship between dietary cholesterol and blood cholesterol is less well understood, although the public generally perceives dietary cholesterol as being the problem. Sabine (1977) has pointed out that man has a limited capacity for absorption of cholesterol and suggested that dietary cholesterol can contribute no more than 40% of the cholesterol in blood plasma. Keys et al. (1965a) arrived at the following equation for predicting the influence of dietary cholesterol on blood cholesterol:

$$\text{Increase in serum cholesterol} = 1.60 + 0.118 \ \text{dietary cholesterol}$$

Thus, if the diet contains from 150 to 350 mg cholesterol/1000 kcal, taking the midpoint of this range (250 mg) and reducing it by 50% (125 mg) would lower plasma cholesterol by only 7 mg/100 ml, or assuming it was 220 mg/100 ml, it would only lower blood cholesterol to 213 mg/100 ml (Sabine, 1977). Total removal of all dietary cholesterol (which is impossible on normal diets) would only reduce plasma cholesterol by 24 mg/100 ml or from 220 mg/100 ml to 196 mg/100 ml (Sabine, 1977). This demonstrates that blood cholesterol is not altered greatly by diet in normal individuals.

Table 5 lists species by their responsiveness to dietary cholesterol. It is clear that man, the mouse, rat and dog show no major change due to diet, whereas the rabbit, monkey, hamster and chinchilla respond rapidly. For man, it is probable that the major inhibitor of the response is associated with poor absorption of dietary cholesterol (Sabine, 1977). Poor absorption of cholesterol may be a compensatory mechanism since recent studies (Samuel and McNamara, et al., 1982; McNamara, 1985, 1987) have suggested that human subjects fall into two groups in their response to adjusting blood cholesterol to dietary cholesterol levels, i.e., compensators (those that reduce synthesis of cholesterol to adjust for dietary levels) and non-compensators (those that do not reduce synthesis as dietary levels of cholesterol increase). McNamara et al. (1987) have found about 30% of human subjects are non-compensators.

Table 5. Effect of Excessive Dietary Cholesterol on Plasma Cholesterol for Various Species[a].

No Gross Change	*Rapid Increase*
Man	Rabbit
Mouse	Monkey
Rat	Hamster
Dog	Chinchilla[b]

[a]Taken from Sabine (1977).
[b]Without associated atherosclerosis.

Taylor et al. (1987) developed a model to determine the effects of controlling serum cholesterol levels between 180 and 300 mg/100 ml on risk from CHD. With persons aged 20 to 60 years of low risk, they calculated that life-long cholesterol reduction would extend life by only 3 days to 3 months. For persons of high risk, a life-long program of cholesterol reduction would extend life by 18 days to 12 months. Thus, controlling serum cholesterol levels has a relatively small benefit, even for high-risk patients.

In conclusion, the relationship between dietary and blood cholesterol is low and probably of little importance. In other words, there is little reason for most humans to be greatly concerned with dietary cholesterol. However, persons having high plasma cholesterol levels should be under the care of a physician who is competent to advise them on methods of reducing blood cholesterol levels.

Saturated Fatty Acids

Animal products, especially red meats, have been criticized due to the concept that saturated fatty acids increase blood cholesterol levels. This concept was based largely on research showing that saturated fatty acids increased plasma cholesterol levels while unsaturated fatty acids lower serum cholesterol (Keys et al., 1965b). An intriguing and important finding by Kritchevesky (1964) was the fact that rabbits fed on various saturated fats while on a cholesterol-free semi-purified diet developed atheromas, whereas those on a commercial diet were atheroma-free.

The effect of various fatty acids on blood cholesterol indicates that all fatty acids do not behave the same. Recently it has been shown that omega-3-unsaturated fatty acids decrease plasma cholesterol (von Lossonczy et al., 1978). These unsaturated fatty acids are found in appreciable amounts in fish lipids and have led to an increase in consumption of fish and fish oils.

Early work (Keys et al., 1965b; Hegsted et al., 1965) suggested that stearic acid (18:0) does not raise plasma cholesterol levels. Recently, an abstract by Bonanome and Grundy (1987) has verified the fact that diets high in both

Table 6. Effects of Diets High in Palmitate (16:0), Oleate (18:1) and Stearate (18:0) on Some Plasma Cholesterol Fractions of Patients in a Metabolic Ward[a].

Diets	*TC*	*TG*	*VLDL-C*	*LDL-C*	*HLD-C*
High Palmitate	217.9	118.7	18.3	149.6	50.0
High Oleate	194.8*	98.8	14.8	127.2*	53.9
High Stearate	185.8*	114.0	17.3	120.2*	48.1

[a]Taken from Bonanome and Grundy (1987). TC = total cholesterol; TG = tricylglycerols; VLD-C = Very low density lipoprotein cholesterol; LDL-C = low density lipoprotein cholesterol; and HDL-C = high density lipoprotein cholesterol.
*Significant at $P<0.05$.

stearate (18:0) and oleate (18:1) decrease total plasma cholesterol and plasma low-density lipoprotein cholesterol in comparison to patients in a metabolic ward fed palmitate (16:0). The data from this study are shown in Table 6.

These studies support the concept that individual fatty acids behave differently in regard to their effects on plasma cholesterol levels. Some of the saturated fatty acids have a plasma cholesterol lowering effect. This is important since stearic and oleic acids are high in animal fats.

Calories

Fat contains 2.25 times as much energy per gram as carbohydrates and proteins. This, no doubt, is the most damning effect of fat. Thus, decreasing the fat content as much as possible while still maintaining palatability would be a worthy goal of meat processors. Actually, there is good evidence for the involvement of obesity in both coronary artery disease and cancer. Reduction of dietary fat and exercise would be the best means of treating the problem of too many calories.

Producing Low-Fat Meat Products

For this discussion, we propose to cover both ground meat and further-processed meats. We will first discuss the amount of fat required to give maximum acceptability and then point out some procedures of achieving a reduction in fat for these products.

Ground Beef and Processed Meats

The National Academy of Sciences sponsored a symposium entitled "The Fat Content and Composition of Animal Products" in December 1974. At that conference, Pearson (1976) presented a paper in which he examined the relationship between palatability and fat content, which indicated that consumers generally prefer ground beef containing 20% to 30% fat. Similarly, whenever the fat content of processed meat products reached 15% or below, they were less acceptable. Other research on meat seems to support these conclusions for ground beef (Cole, 1960; Glover, 1968; Huffman and Powell, 1970; Cross et al., 1980; Parizek et al., 1981), for ground beef with added soy protein (Cross et al., 1975; Drake et al., 1975), for various pork cuts (Kauffman et al., 1964; Rust et al., 1972; Davis et al., 1975; Bereskin et al., 1978), and in processed meats (Valvano, 1983).

Although there is some controversy about the role of fat on meat flavor, with some researchers claiming that fat enhances flavor (Kauffman et al., 1964; Rakosky, 1970) and other investigators reporting that fat level had no effect on flavor (Drake et al., 1975; Cross et al., 1980), this is not surprising, considering the nature of the contribution of fat to meat flavor. Kramlich and Pearson (1958) demonstrated that the characteristic meaty flavor resides in the water-soluble fraction, while Hornstein et al. (1960, 1963) verified the earlier study showing that the meaty flavor was in the water-soluble fraction, while the species-characteristic flavors come from the lipid fraction. Bearing these basic meat flavor studies in mind, it is not surprising that the studies relating meat flavor to fat content are frequently contradictory.

The relationship of fat content to tenderness and juiciness, however, is clearer. Blumer (1963) in an excellent review found marbling fat accounted for 5% of the variation in tenderness and 16% of the variation in juiciness. These data verified an earlier but less extensive study by Wellington and Stouffer (1959). Although the level of fat required for maximum palatability in ground beef and processed meats is no doubt higher than that required for marbling, there appears to be a definite requirement for some minimum fat content for palatability (Pearson, 1976). The minimum level of fat required for acceptability seems to be about 15% unless other steps are taken, as will be discussed under production of low-fat processed meats.

Production of Low-Fat Processed Meats

Valvano (1983) produced low-fat New England Brand sausage by using either 5%, 15% or 25% fat in the formulation. He also investigated: (1) adding one-half of the nitrite and all of the salt 48 hours before processing and adding the remaining nitrite at the time of processing; or (2) adding all of the nitrite and all of the salt, followed by immediate processing.

Table 7 presents the panel scores for saltiness, chewiness and overall acceptability. Results indicate that the overall score was highest for the 5% fat sample and lowest for the 25% fat product. Furthermore, the sample containing 5% fat was also rated highest for salt level and chewiness, but the 25% fat product had a significantly lower LEE-Kramer shear press value at peak force, meaning the high-fat sample was

Table 7. Panel Acceptability Scores and LEE-Kramer Shear Readings for New England Brand Sausage Containing Different Fat Levels[1].

	Panel Scores[2]		
Percent Fat - %	*5*	*15*	*25*
Saltiness	5.14[a]	4.70[b]	3.95[c]
Chewiness	4.78[a,b]	5.02[b]	4.42[a]
Overall Acceptability	5.10[a]	4.79[b]	3.84[c]
LEE-Kramer Shear Press[3]	171.2[a]	126.2[b]	106.0[c]

[1]Data taken from Valvano (1983)
[2]Panel scores on the same line followed by same superscript letter were not significantly different ($P<0.05$). Panel scores were based on 7-point hedonic scale where 1 = dislike extremely and 7 = like extremely.
[3]LEE-Kramer shear values are expressed as peak force in kgs.

more tender. This study demonstrated that it is possible to produce quite an acceptable 5% fat New England Brand sausage. However, this product tends to be lower in fat than most other sausages, with the 25% fat formulation being too fatty in appearance.

Production of low-fat sausages, however, appears to require special processing techniques. This is allowed under a recent FSIS ruling that lets the amount of water be increased as the fat content is decreased. This ruling appears to have been designed to allow processors to produce low-fat products. The amount of water can be readily added prior to processing but unless something is added to bind it, much of the water added will be lost during processing. There is, however, very little information on the subject, although many of those working in the industry appear to know how to produce 90% and 95% fat-free sausage products.

Binders that are being used commercially include salt and dextrose. Gillett (1987) has indicated that some processors are adding as much as 8% dextrose and 4% salt to give a total of 12% of added substance to bind the extra water added in producing 90% to 95% fat-free processed meats. These products are good water binders but suffer from their high sodium content and brown or char during high-temperature cooking.

Means and Schmidt (1987) have reviewed the properties of some of the polysaccharides that have been used in food systems, with some of them being shown in Table 8. These include agar, alginates, gum arabic, carboxymethylcellulose and similar cellulose derivatives, carrageenans, cellulose, furcellan, guar gum, locust bean gum, pectin, starch and its derivatives, synthetic polymers, tragacanth and xanthan gum. A number of these compounds are apparently already being used in production of low-fat meat products. In addition, soy proteins, either as soy flour, soy concentrate or soy isolate, are also being used successfully for binding of water and fat.

Table 8. Some Polysaccharides That Are Used in Food Systems[a].

Agar
Algin
Arabic
Carboxymethylcellulose and other cellulose derivatives
Carrageenans
Cellulose
Furcellaran
Guar gum
Locust bean gum
Pectin
Starch and its derivatives
Synthetic plymers
Tragacanth
Xanthan gum

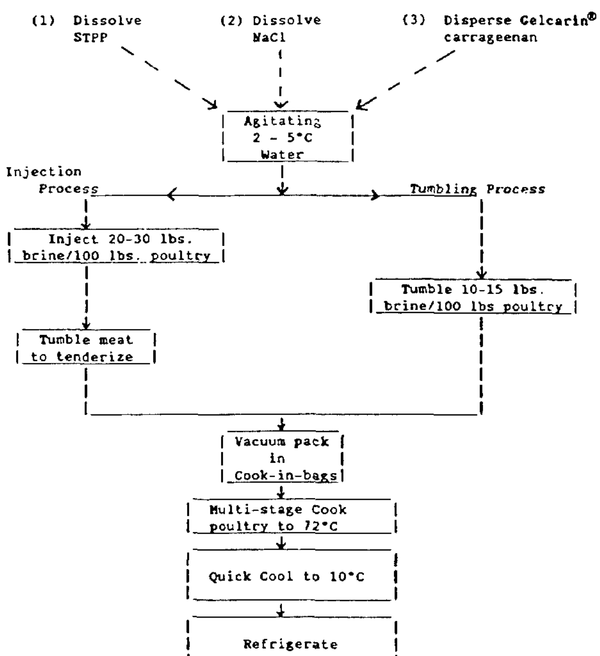
[a]Taken from Means and Schmidt (1987).

Foegeding and Ramsey (1986) produced low-fat (10%) frankfurters using iota-carrageenan, kappa-carrageenan, guar gum, locust bean gum, xanthan gum, methylcellulose, and a locust bean/kappa carrageenan mixture in order to evaluate the effect of replacing fat with water or water-gum suspensions. In this study, kappa- and iota-carrageenan appeared to be the most beneficial for manufacturing of low-fat frankfurters. Increased moisture retention was achieved with no significant change in hedonic scores when compared to control (27% fat) frankfurters.

Table 9 presents a formulation to produce different strength brines using carrageenan to pump poultry products. The use of carrageenan in poultry products has been claimed to have the following benefits: (1) It increases yields of processed poultry products; (2) It improves texture and sliceability; (3) It improves moisture and flavor retention; (4) It improves freeze-thaw stability; and (5) It reduces processing plant down-time (FMC, 1986).

Fig. 6 shows a suggested scheme for processing of poultry products on addition of 20% to 30% brine. As shown

Figure 6



Typical Processing Procedure for Poultry Products Using Carrageenan. From FMC Corporation (1986).

Figure 7

Ingredient / Characteristics	Phosphate	Salt	Starch	Protein	Gelcarin® Carrageenan
Moisture Retention	X		X	X	X
Oxidation/Flavor	X	X			X
Texture	X			X	X
Sliceability					X
Brine Viscosity					X
Freeze-Thaw Stability	X				X
Dispersability		X			X

Characteristics That Are Improved by Carrageenan Mixture and Ingredients Responsible. From FMC Corporation (1986).

Table 9. Carrageenan Brine Formulations for Pumping or Tumbling of Poultry Products[a].

Ingredients	*10% Brine Injection*	*20% Brine Injection*	*30% Brine Injection*	*% Composition in Total Product Weight*
Water (5°C)	72.5%	85.0	89.0	0
NaCL	16.5	9.0	6.6	1.5
STPP	5.5	3.0	2.2	0.5
Gelcarin carrageenan*	5.5	3.0	2.2	0.5

*Gelcarin SA 911
[a]FMC Corporation (1986).

in the diagram, the brine can either be added by pumping or tumbling. After that, it is vacuum-packaged in cook-in bags and is cooked and cooled as suggested by the manufacturers (FMC, 1986).

Figure 7 presents a chart showing the constituents present in a commercial preparation of carrageenan and the constituents responsible for improvement of poultry products. It is interesting to note that the manufacturer claims that the carrageenan mixture has a beneficial effect on moisture retention, oxidation/flavor, texture, sliceability, brine viscosity, freeze-thaw stability and dispersability (FMC, 1986). The use of the carrageenan mixture is claimed by the manufacturer to have the following advantages in producing low-fat (15% fat) frankfurters: (1) It enhances mouthfeel in reduced-fat meat products; (2) It improves texture properties; (3) It aids in retention of moisture; and (4) It helps to stabilize the emulsion.

Table 10. Formulations for Producing Control and Low-Fat Frankfurters Using Viscarin® Carrageenan[a].

	Formulation (Percent)	
Ingredients	*Control*	*Carrageenan Added*
Lean Meat Blend (3.6% Fat)	20.33	35.42
Fat Meat Blend (48.1% Fat)	52.47	24.38
Water	21.73	34.43
Salt	2.20	2.20
Seasoning	3.22	3.22
Sodium erythorbate	0.04	0.04
Sodium nitrite	0.012	0.012
Viscarin® type carrageenan	–	0.30
	100.00%	100.00%

[a]FMC Corporation (1987)

Table 10 presents a formulation for producing low-fat frankfurters using a carrageenan mixture. The frankfurters were then tested for acceptability by a 25-member consumer type panel. The results are summarized in Table 11 and indicate that the panel found the color, flavor and general acceptance of the frankfurters manufactured with the carrageenan mixture to be significantly more acceptable than the control. There was, however, no measurable difference in texture.

The information reported on carrageenans has been supplied by the manufacturer. The data illustrate how one product can be used to produce low-fat meat and poultry products. It is not intended to be an endorsement, since other additives apparently have similar properties. There are, no doubt, other additives that have similar advantages in producing low-fat meat products.

These studies and investigations with soy proteins (Drake et al., 1975) demonstrate that the lowering of fat levels in meat products is best achieved by adding water and a satisfactory binder to hold the water. Thus, simple removal of fat without substituting water and a satisfactory water-binding agent does not give as good results as the water substitution procedure. This is also probably true with ground beef, where most studies have indicated that removal of fat results in a less desirable product. The concept of adding water and a binding agent to compensate for water removal, which is now allowed by FSIS regulations, seems to be sound and results in improvement in the properties of low-fat meat products.

Table 11. Panel Acceptability Scores for Control (30% Fat) and Reduced-Fat (15% Fat) Frankfurters Made Using Carrageenan Mixture[a].

Product	*Color*	*Texture*	*Flavor*	*General Acceptance*
Viscarin type Carrageenan 15% fat frank	6.92*	7.00	7.00*	7.08*
Control 30% fat frank	6.04	6.84	6.20	6.08

*Significantly different from control at $P<0.05$.
[a]FMC Corporation (1987)

Summary

Consumers prefer low-fat products and are willing to pay a premium for them. Low-fat products are difficult to produce simply by removal of fat. In fact, removal of fat may actually increase cholesterol levels in meat products. There is, however, very little data to support attempts to reduce cholesterol levels in meat and meat products, since cholesterol in the diet is not important for most human beings but rather blood levels of cholesterol is the real issue. Data indicate that blood cholesterol levels are not influenced greatly by dietary cholesterol except for non-compensators, who are unable to reduce synthesis of cholesterol as cholesterol in the diet increases.

Studies on the amount of fat necessary for palatability of ground beef and processed meats have suggested that a minimum of 20% to 25% is needed. However, recent work has demonstrated that low-fat processed meat products can be produced by substituting water and a binder for fat. Further work is needed to determine which and how much of these binders can be used for producing low-fat meat products.

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