Fat Substitutes and Fat Modification in Processing

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Introduction

The present consumption of prepared meats is influenced by several factors, the most significant of these being: diet/health concerns and government recommendations; the aging population; economic conditions, which ultimately affect purchasing patterns; consumer expectations for value; and changes in the meat industry regarding fat.

Diet/Health Concerns and Government Recommendations

Coronary heart disease (CHD) continues to be the number one killer of adults in the United States, according to The Surgeon General's Report on Nutrition and Health (McGinnis and Nestle, 1989), and the primary dietary priority to reduce the risk of heart disease is a reduction in fat consumption. Among the 10 leading causes of death in the U.S., coronary heart disease, certain types of cancers, strokes, diabetes mellitus and atherosclerosis have been associated with dietary excesses and nutrient imbalances. Nearly one-fourth of the U.S. population, 34 million people, are overweight and 13 million of these are severely obese.

In 1979, the Surgeon General's Report urged Americans to improve their health by: reducing dietary intake of saturated fat, cholesterol, salt and sugar; increasing their consumption of complex carbohydrates; and taking in only enough energy to maintain desirable body weight, or to reduce if overweight. The United States Department of Agriculture and Department of Health and Human Services issued similar dietary guidelines in 1980 which are summarized as follows:

Eat a variety of foods.
Maintain desirable body weight.
Avoid too much fat, saturated fat and cholesterol.
Avoid too much sodium.
Eat foods with adequate starch and fiber.
If you drink alcoholic beverages, do so in moderation.
Avoid too much sugar.

The primary conclusion of the Surgeon General's Report on "Nutrition and Health" (1988) was that overconsumption of foods high in fat are often at the expense of foods high in complex carbohydrates and fiber (vegetables, fruits, and whole-grain products). Dietary recommendations (listed above) made in 1980 have remained in effect but with added emphasis on increased consumption of foods high in fiber and perhaps certain vitamins and minerals. It was also noted that food manufacturers could contribute to improving the American diet by increasing the availability of palatable low-calorie or low-fat foods.

Data from the USDA's Nationwide Food Consumption Survey (1977-78) indicated that Americans consume about 37% of their total calories from fat, and that 63% of the total dietary fat comes from animal products, specifically 42% from red meats, poultry and fish. Most nutritionists and clinical scientific organizations recommend consuming no more than 30% of total calories per day as fat and limiting saturated fat to $\leq$10% of total calories.

Aging Population

Population growth in the U.S. has slowed and Americans as a whole are getting older, with a projected population of 268 million by the year 2000. The "baby boomers" are expected to make up 45% of the 35-50 age group (74 million people) and in combination with the 50-60 age group will have the most disposable incomes. The 1990's will be an era with an increased emphasis on low-calorie, low-fat diets where healthy, active older adults will choose foods that sustain health.

Consumer Expectations for Value

With trends toward an older population, larger numbers of working women, a desire for healthy, low-calorie meat foods and the popularity of convenience foods, a greater diversity of products is anticipated to meet consumer demands. Consumers are becoming more sophisticated and discretionary in their purchases and are demanding high-quality food that is convenient and priced to reflect its value. The meat industry has also become more "consumer driven" and less "commodity driven" with the amalgamation of individual companies into larger conglomerates. Low-fat prepared meat products must taste good, offer consistent quality and value and provide a healthier alternative to traditional products.

Food consumption data (Figures 1-4) indicate that Americans are favoring foods that are fresh, low-fat and sweet (Putnam, 1990). Nine commercial fresh vegetables increased 20% more than in 1980 and 37% above 1971. Fresh fruit consumption gained 19 pounds per capita from the 1971-73 annual average to a total of 94 pounds in 1988 due entirely to sharp increases in fresh noncitrus fruits such as bananas, grapes, apples, avocados, pineapples and strawberries. From 1966-88, caloric sweetener consumption increased 16% to 133 pounds, but with increased use of high-fructose corn syrup, the use of refined sugar has dropped from 102.3 to 61.7 pounds. Low-calorie sweetener use was

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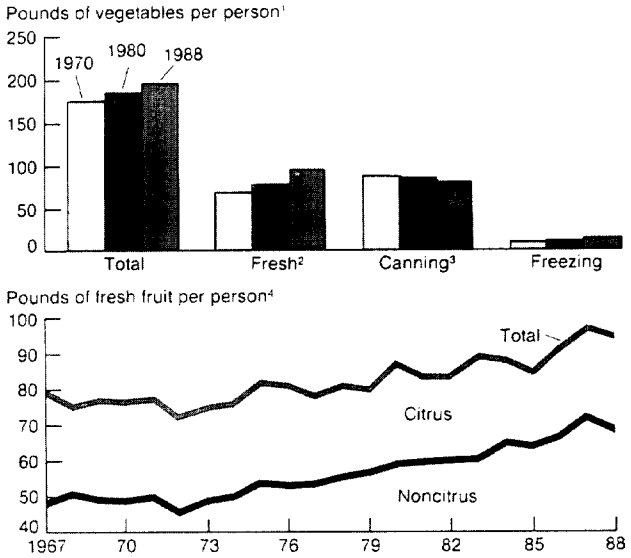
Figure 1

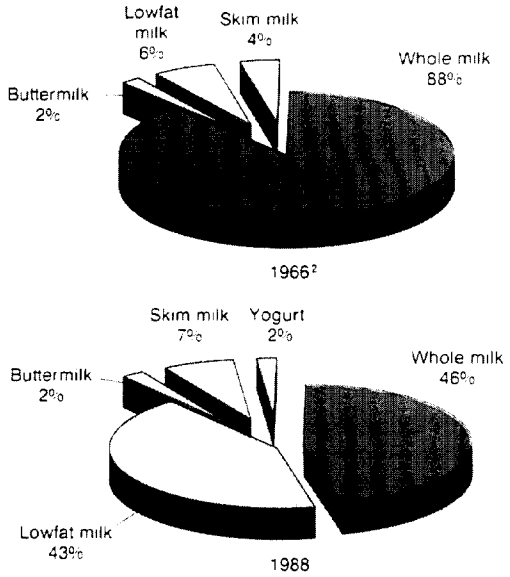
The American Diet Includes More Fresh Fruits and Vegetables



[1]Farm weight. [2]Asparagus, broccoli, carrots, cauliflower, celery, sweet corn, lettuce, onions, and tomatoes. [3]Tomato products are about 60 percent of the total.
[4]Retail weight.
Source: *Food Consumption, Prices, and Expenditures 1967-88.*
Contact: Judith Jones Putnam (202) 786-1870.

Figure 2

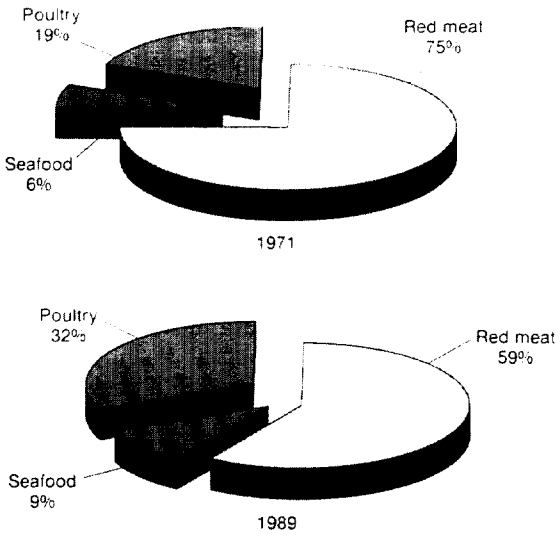
The Use of Whole Milk Has Declined Dramatically[1]



[1]Product weight. [2]Yogurt = less than 0.2 percent.
Source: *Food Consumption, Prices, and Expenditures 1967-88.*
Electronic database.
Contact: Judith Jones Putnam (202) 786-1870.

Figure 3

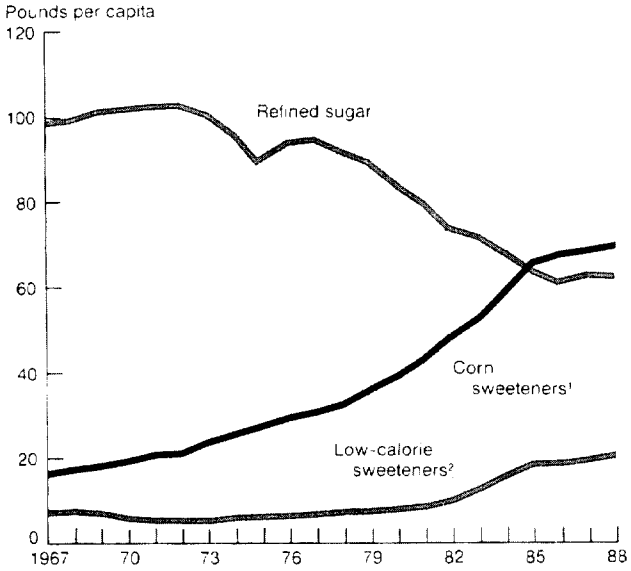
Poultry and Seafood's Share of Per Capita Meat Consumption Has Grown



[1]Boneless, trimmed basis.
Source: *Food Consumption, Prices, and Expenditures 1967-88.*
Contact: Judith Jones Putnam (202) 786-1870

Figure 4

Total Sweetener Consumption Is Up, While Low-Calorie Sweeteners Are Becoming More Popular



[1]Dry basis. [2]Sugar-Sweetness equivalent.
Source: *Food Consumption, Prices, and Expenditures 1967-88.*
Contact: Judith Jones Putnam (202) 786-1870.

about 20 pounds per person or 13% of the total market in 1988 compared with 6% in 1980. In 1989, total meat, poultry and fish consumption reached a record 187 pounds per person (boneless, trimmed equivalent), six pounds more than in 1971. However, consumption on the average was 24 pounds less for red meat, 26 pounds more for poultry, and four pounds more for fish and shellfish than in 1971.

Changes in the Meat Industry Regarding Fat

Results from the National Consumer Retail Beef Study and the National Beef Market Basket Survey (Savell et al., 1987, 1989, 1991) revealed that consumers would purchase more beef if the fat were closely trimmed. By early 1988, the average fat thickness for retail cuts was ⅛ inch with over 42% of the retail cuts having no external fat. These studies indicated a significant change in consumer attitude toward fat and have documented the meat industry's move toward low-fat meats. Continued diet/health concerns regarding the consumption of saturated fat and cholesterol have led to a more segmented market with an emphasis on "lite" or "low-calorie" eating.

The red meat industry has "lagged" behind to develop and merchandise reduced-fat products, but increased demand for poultry products and industry consolidation have placed additional emphasis on expanding traditional and new low-fat items. Recent moves by a major "fast food" chain (McDonald's) to incorporate low-fat meat products into their menu have expanded the interest in development of new processed meat foods. Innovative uses and greater acceptance of natural food ingredients such as vegetable starches, gums, soy proteins, milk proteins and bran or fiber-based grain products have also fostered the development of low-fat meats. Relatively recent changes in labeling policy (40% rule) for emulsified meats such as frankfurters and bologna have allowed the production of reduced-fat, emulsified sausages by allowing reductions in fat with subsequent increases in moisture. Further changes, which are currently pending, to eliminate the prominent labeling requirement of binders and extenders in sausages should also promote the development of new low-fat products.

Concerns About Fat in Processed Meats

Processed meats have traditionally had higher fat contents than whole-muscle cuts from which the fat could be trimmed. Frankfurters and bologna, for example, may have as much as 30% fat while fresh pork sausage is allowed to contain up to 50% fat. Other examples include Italian sausage which may have up to 35% fat and ground beef which can have as much as 30% fat. Because of the caloric density of these processed products, they are viewed as foods which contribute a substantial amount of fat calories to the diet when consumed on a regular basis. However, processed products have the greatest opportunity for fat reduction and/or modification because their composition can be altered by reformulation with a fat replacement.

Meat Products Having Potential for Fat Reduction

Numerous products have potential for fat reduction, including the following:

- Hamburger Patties (Fast Food Chains, School Lunch Programs, Day Care Facilities, Military, Food Service, Hospitals, Health Care Facilities)
- Coarse Ground Sausages (Fresh, Cured)
- Emulsified Sausages (Frankfurters, Bologna, Meat Patties)
- Restructured Products (Meat Nuggets, Finger Foods, Extruded Snacks)
- Fermented Sausages and Snack Sticks
- Precooked Products (Microwave-Ready)
- Sausage Biscuits
- Patties and Steaks
- Salisbury Steaks
- Meat Balls
- Pizza Toppings

Categories of Fat Replacements for Meat Products

Fat replacements or substitutes are ingredients which contribute fewer or no calories to formulated foods without altering flavor, mouthfeel, viscosity or other organoleptic properties. Most are used for partial rather than total replacement of the fat. The major categories include:

- Added Water
- Proteins (Soy, Milk, Whey, Wheat, Oats, Corn)
- Carbohydrates (Starches, Gums, Maltodextrins, Dextrins)
- Synthetic Compounds (Sucrose Polyester, Polydextrose)

Outlined in Tables 1-3 are potential fat replacements for processed meats, some of which are approved for use by the USDA-FSIS while others are pending approval by FDA or are experimental.

Selected Studies of Fat Replacements

Added Water

Fat can be reduced in processed meats by using leaner meats, which increases the cost of the product substantially, or by replacing a portion of the animal fat with water or other ingredients having fewer calories. The USDA now permits fat and added water in cooked sausages to substitute for one another provided that their total does not exceed 40% and that the fat content is no greater than 30% (USDA, 1990). This rule allows a great deal of flexibility in formulating low-fat cooked sausages since fat can be replaced by water. If the fat content in emulsion-type sausages is reduced and added water remains constant (essentially increasing the lean content), the product becomes firmer, more rubbery, less juicy, darker in color and less acceptable from a cooked yield standpoint (Rongey and Bratzler, 1966; Hand et al., 1987;

Table 1. Potential Protein-Based Fat Replacements for Processed Meats.

Fat Replacement (Source)	*Calories/g (Dry Weight)*	*Comments*
Soy Flour/Textured Soy (~50% Protein)	4	Used at 3.5% level; if higher, loss of Standard of Identity. Binder/extender, rehydrate at 3 parts water 1 part protein. Ground meat products.
Soy Concentrate (~70% Protein)	4	Same as above.
Soy Isolate/Textured Isolate (90% Protein)	4	Used at 2.0% level; if higher, loss of Standard of Identity. Binder/extender, rehydrate at 5 parts water 1 part protein. Bland flavor. Can form gel. Coarse and fine ground products. Patties and nuggets.
Wheat Gluten (70% Protein)	4	Used at 3.5% level, if higher, loss of Standard of Identity. Binder/extender, mix dry then add 3 parts water to 1 part protein. Forms elastic gel when heated above 185° F in canned meats.
Calcium Reduced Dried Skim Milk (Ca Lactate at 10% of binder) (35% Protein)	4	Used at 3.5% level, if higher, loss of Standard of Identity. Some water binding, produces lower tensile strength. May need to increase spicing levels.
Whey Protein (19 to 33% Protein)	4	Same as above.
Whey Protein Concentrate (~75% Protein)	4	Used at 3.5% level, if higher, loss of Standard of Identity. Restructured meats primarily.
Sodium or Calcium Caseinate Milk Hydrolysate (~90% Protein)	4	Used at 2.0% level, if higher, loss of Standard of Identity. Enhances water retention (rehydrate at 5 parts water 1 part caseinate) or used in fat preemulsions (8:8:1 fat:water:caseinate). Sausage, emulsion-type products, restructured meats, coarse chopped sausages.

Claus et al., 1989). Claus et al. (1989) substituted added water for fat in bologna formulations ranging from 30% fat/10% added water to 5% fat/35% added water and found low-fat, high-added water bologna to be generally less firm, more cohesive, juicier and darker with greater cooking and purge losses than the 30% fat/10% control of similar protein content (Table 4). Regression analyses indicated that bologna with 10% fat would require 24.3% added water to approximate the sensory firmness of bologna with 30% fat/10% added water. In a second study by Claus et al. (1990), massaging of raw materials nor preblending a 10% fat/30% added water bologna was sufficient to prevent cooking losses and purge accumulation 2% greater than the control. They also noted that the low-fat bologna required less total compression energy, had lower fracturability and hardness values, and was more cohesive and springier. Park et al. (1990) found low-fat (14% to 16%) frankfurters containing ~ 14% to 16% added water and high-oleic sunflower oil (HOSO) to be as acceptable to consumer panelists as control frankfurters with 29% (animal) fat and in this case, processing yields of the low-fat franks (89.4%) were similar to the control (87.9%). Ahmed et al. (1990) processed pork sausage at 15%, 25% and 35% fat levels with 3% and 13% added water. Increased amounts of added water in the low-fat sausages (15% and 25%) resulted in increased cooking losses but consumer panelists rated overall palatability of the low-fat, added water sausages to be equivalent to the 35% fat (no added water) control.

Substitution of fat with added water reduces caloric density, but can alter the physical, sensory and textural characteristics of low-fat products. In cooked sausages, such as frankfurters and bologna, lowering the fat content to ~ 10% by substitution with added water appears to reduce cooked yield, increase vacuum package purge, and "soften" the texture. Although limited studies are available, increasing the amount of added water may affect the microbial shelf-life of the product and alter flavor/texture parameters with prolonged refrigerated storage.

Protein-Based Substitutes

Several plant and animal-based proteins have been used in processed meat products to increase yields, reduce formulation costs, enhance specific functional properties and decrease fat content. Examples of these protein additives are: wheat flour, vital wheat gluten, soy flour, soy protein concentrate, soy protein isolate, textured soy protein, cottonseed flour, oat flour, corn germ meal, nonfat dry milk, calcium-

Table 2. Potential Carbohydrate-Based Fat Replacements for Processed Meats.

Fat Replacement (Source)	*Calories/g (Dry Weight)*	*Comments*
Gums or Hydrocolloids		
Carrageenan, Kappa and Iota (Seaweed)	<1	Used alone at 0.3 to 0.7% levels and/or in combination with starches, soy protein isolate, sodium caseinate and other ingredients. Up to 1% allowed in meat products. Gelcarin®, Viscarin®.
Konjac Flour (Amorphophallus Tuber)	<1	Has 65% fiber (polysaccharide) with a mouthfeel similar to shortening or fat. Possible use in coarse ground meat products (hamburger or sausages) or precooked items. Synergistic with kappa carrageenan and starch. Standardized with 8 to 12% dextrose. Nutricol®.
Alginate, Sodium or Calcium	<1	Use at ≤1% in conjunction with Ca carbonate (0.2%), lactic acid/Ca lactate (or glucono delta lactone) not to exceed 0.3%. Added mixture cannot exceed 1.5% of formulation. Restructured meats.
Locust Bean Gum	<1	Possible use in coarse and emulsion sausages in combination with kappa carrageenan at ≤1%. Compatible with all gums.
Starches		
Corn Starch Maltodextrin	4	Use up to 3.5% singly or in combination with binders; if higher, loss of Standard of Identity. Suggested for sausages. Has a DE of 5. DE is a measure of reducing sugar content calculated as % dextrose. DE of dextrose = 100, while DE of starch = 0. Maltrin® M040.
Modified Waxy Maize	4	Same as above. Firm-Tex®.
Tapioca Dextrins and Maltodextrins	4	Same as above. N-Oil®, pregelatinized.
Potato Starch Maltodextrin	4	Same as above. DE of <5. Paselli SA2.
Modified Potato Starch	4	Same as above. Sta-Slim™ 143.
Oat Fiber	4	Same as above. Better Basics™ #770.
Rice Flour	4	Same as above.
Cellulose Derivatives		
Microcrystalline Cellulose	<1	Use level of ~3.5% in ground meat patties. Solka-Floc®, Avicel®.
Methylcellulose Carboxymethylcellulose	<1	Use level varies from 0.25-1.0%; may be combined with gums. Methocel®.

reduced nonfat dry milk, caseinates, whey proteins, surimi, blood plasma and egg proteins. Singly or collectively, most protein ingredients included in cooked sausages are allowed at levels up to 3.5% of the formulation, but soy protein isolates and caseinates (~ 90% protein) are restricted to ≤2%.

Soy proteins have traditionally been the product used most for extending ground beef, meat patties, pepperoni, precooked pizza toppings, and other formed meats. Extension of ground meats up to 30% with rehydrated proteins is feasible, but attention to their formulation is required to avoid altering sensory traits. With the current emphasis on low-fat meats, animal and plant-based proteins offer potential as partial fat substitutes for processed products.

Ground beef. Drake et al. (1975) formulated ground beef patties to contain 0%, 15%, 20% and 25% added textured soy protein (TSP) at each of four fat levels (15%, 20%, 25% and 30%). Total cooking losses were found to be less with the addition of soy protein while fat loss was dependent upon the amount of fat in the patty. Moisture loss, however, was highly dependent on the level of soy protein in the beef patties. Sensory data indicated that flavor declined with increasing levels of TSP, but fat level did not affect sensory parameters. In beef patties adjusted to a 20% fat level and 10% of the meat replaced with rehydrated defatted flours, protein concentrates and isolates from glandless cottonseed, peanuts and soybeans, Ziprin et al. (1981) found that extended patties had higher cook yields, contained less fat, and

Table 3. Potential Synthetic Compounds for Fat Replacement in Processed Meats.

Fat Replacement (Source)	*Calories/g (Dry Weight)*	*Comments*
Polydextrose	1	~1.0% use level as a partial fat substitute. Protects proteins from denaturation and water loss upon thawing. Possible use in brines and meat emulsions.
Olestra (Sucrose Polyester)	0	Experimental, pending FDA approval. Proctor & Gamble Co. High temperature oil or shortening substitute.
EPG (Esterified Propoxylated Glycerols)	0	Experimental. ARCO Chemical Co. Fat and oil substitute with a structure similar to natural fat. Resistant to enzymatic hydrolysis.
DDM (Dialkyl Dihexadecymalonate)	0	Experimental. Frito-Lay, Inc. High temperature oil substitute. Minimally digested.
TATCA (Trialkoxytricarballate)	0	Experimental. Best Foods. Oil substitute and possible resistance to hydrolysis by digestive enzymes.

Table 4. Treatment Means For Total Cook Loss And Purge Loss During Storage Of Bologna.

Treatment[f]	*Cook loss*[g]	*Storage purge loss (%)*[h]	
% Fat/% AW	*(%)*	*Slices*	*Chubs*
30/10	5.8[e]	1.6[a]	1.1[c]
20/10	7.2[d]	1.6[a]	1.0[c]
20/20	7.3[d]	2.0[cd]	1.8[ab]
15/15	7.8[d]	1.8[de]	1.4[bc]
15/25	8.8[c]	2.3[bc]	1.9[ab]
10/20	9.1[bc]	1.9[de]	1.6[abc]
10/30	9.8[b]	2.5[b]	2.1[a]
5/25	10.7[a]	2.1[cd]	1.9[ab]
5/35	11.2[a]	3.0[a]	2.1[a]

[a-e] Mean values in the same column with unlike superscript letters are different ($P<0.05$)
[f] Treatment: %Fat/%AW treatment combination, AW = USDA added water
[g] Cook loss: percentage total cook loss from smokehouse processing plus chill loss
[h] Storage purge loss: percentage purge loss based on initial net weight
Claus et al. (1989)

were not different from all-beef patties in sensory quality. Ground beef patties adjusted to 22% fat and extended with 20% rehydrated concentrate or flour with or without iron and zinc fortification were reported by Berry et al. (1985) to be more tender than all-beef patties or those with soy isolate (SPI) (Tables 5 & 6). Patties with soy flour had the highest cooking yields while those with soy isolate were more similar in texture to all-beef patties than those containing soy concentrate or flour. Patties extended with soy flour or concentrate had a higher incidence of soy flavor than all-beef or soy isolate patties. Brown and Zayas (1990) used hydrated corn germ protein flour in beef patties (20% fat) at levels of 10%, 20% and 30% and observed extended patties to have higher cooking yields, greater water holding capacity and pH. They also noted that the meaty aroma and flavor in extended patties decreased with increasing levels of corn germ protein. In a similar study, Reitmeier and Prusa (1991) added 0%, 2.5% and 5% dry- and wet-milled corn germ flour to raw pork patties having 10%, 20% or 30% fat and found decreased cooking losses of 9% and 7.5%, respectively, for dry- and wet-milled flour at the 5% level. Textural characteristics decreased as the amount of dry-milled flour increased in the patties.

Cooked sausages. Cooked sausages offer great potential for fat reduction and some proteins have been tested as fat replacements. Sofos and Allen and Sofos et al. (1977) reported that incorporation of up to 45% of hydrated TSP in wiener-type products having 10% to 20% fat and 45% lean beef did not adversely affect emulsion stability. However, wieners high in soy and low in fat showed increased shrink losses during heat processing. Results from these studies indicate that an acceptable wiener-type product can be produced with a total lean content of 45% to 50%, 15% to 20% fat, 5% hydrated (1:4) SPI and 25% to 30% hydrated (1:2) TSP. Hoogenkamp (1989) also indicates that franks with

Table 5. Tenderness, Detectable Connective Tissue, Webbed Tissue, Shear Force and Newton Mean Values and Standard Deviations for All-Beef and Beef-Soy Patty Formulations.

Formulation	Dry soy in the rehydrated soy that was added %	Initial tenderness[a]	Final tenderness[a]	Connective tissue amount[a]	Webbed tissue[b]	Shear force, kg	Newton, kg/cm²
All-beef ground beef	0.0	4.7±0.8[d]	5.1±0.9[d]	5.1±0.9[e]	4.0±2.1[c]	11.5±1.2[c]	43.6±3.5[c]
Ground beef with soy isolate	22.2	4.8±0.5[d]	5.3±0.6[d]	5.5±0.8[d]	2.2±1.2[d]	7.8±2.5[de]	29.7±4.7[de]
Ground beef with soy isolate, Fe and Zn fortified	22.2	5.0±0.9[d]	5.4±0.7[d]	5.6±0.7[d]	2.7±2.4[d]	8.7±1.9[d]	31.4±4.3[d]
Ground beef with soy concentrate	27.8	5.7±0.6[c]	6.1±0.7[c]	6.1±0.7[c]	2.2±2.1[d]	7.5±1.4[de]	28.6±3.8[de]
Ground beef with soy concentrate, Pe and Zn fortified	27.8	5.7±0.5[c]	6.1±0.6[c]	6.0±0.7[c]	3.2±2.7[cd]	7.8±1.7[de]	28.3±4.2[de]
Ground beef with textured soy flour	35.7	5.6±0.7[c]	6.0±0.5[c]	6.1±0.6[c]	2.0±1.8[d]	7.8±1.5[de]	31.6±4.6[d]
Ground beef with textured soy flour, Fe and Zn fortified	35.7	5.8±0.8[c]	6.2±0.5[c]	6.3±0.6[c]	2.2±2.3[d]	6.9±1.0[e]	25.5±3.7[e]

[a] Values based on eight-point structured scales where 8 = extremely tender and no connective tissue: 1 = extremely tough and abundant in connective tissue.

[b] Values based on 15 cm unstructured scale. High numbers indicate a high amount of webbed tissue, low numbers indicate a low amount of webbed tissue.

[cde] Means within a column with different superscripts are significantly different ($P<0.05$).

Berry et al. (1985)

Table 6. Ground Beef Flavor Intensity and Frequency of Other Detected Flavors.

Formulation	Dry soy in the rehydrated soy that was added, %	Ground beef flavor intensity[b]	Flavor note and percent occurrence within formulabion[b]							
			Sour	Bitter	Metallic	Sweet	Rancid	Fishy	Soy	Other
All-beef ground beef	0.0	4.1±0.9	4.5	1.8	13.5	5.4	49.5	13.5	2.7	9.0
Ground beef with soy isolate	22.2	4.1±0.5	13.8	3.4	6.9	8.6	39.7	3.4	5.2	19.0
Ground beef with soy isolate, Fe and Zn fortified	22.2	4.1±0.8	3.6	5.4	10.7	1.8	51.8	5.4	5.4	16.1
Ground beef with soy concentrate	27.8	4.2±0.9	7.0	1.7	24.6	8.8	15.9	0.0	17.5	24.6
Ground beef with soy concentrate, Fe and Zn fortified	27.8	4.0±0.9	7.9	3.2	17.5	7.9	27.0	0.0	17.5	19.0
Ground beef with textured soy flour	35.7	4.0±0.8	2.6	7.7	10.2	23.1	16.6	1.3	21.8	16.6
Ground beef with textured soy flour, Fe and Zn fortified	35.7	3.9±0.9	1.4	4.1	9.6	30.1	16.4	0.0	23.3	15.1

[a] Mean values and standard deviations based on an eight-point structured scale where 8 = extremely intense in flavor and 1 = extremely bland in flavor

[b] Values represent percent occurrence of a flavor in relation to all the other flavor notes identified within a formulation

Berry et al. (1985)

10% fat can be produced with 2.0% to 2.4% hydrolyzed isolated milk protein. Gilchrist (1987) formulated canned Vienna sausages containing 12% fat and 3.5% vital wheat gluten (VWG), milk protein isolate (MPI) or soy protein concentrate (SPC) with or without sodium tripolyphosphate (.23%). Canned yields were higher for all protein treatments and low-fat sausages tended to be darker than the 30% fat control. Sausages with VWG, MPI or SPC with or without phosphate were springier, more cohesive, firmer and less juicy (except VWG).

Although protein ingredients are widely used in meat patties and processed meats, further refinements could benefit sensory and textural characteristics of these products. In some cases, synergistic effects may be possible with the combined use of proteins, starches and/or hydrocolloids.

Carbohydrate-Based Replacements

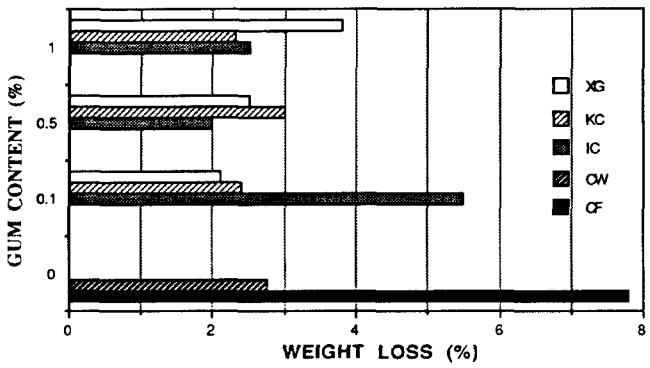
Most carbohydrates which are available for use as fat substitutes in processed meats fall into the category of being a gum (hydrocolloid), starch or cellulose-based derivative. These compounds will likely play a key role in the development of new low-fat meats and examples are shown in Table 2.

Gums or hydrocolloids are used to regulate viscosity, form gels, stabilize emulsions, suspend particulates, control crystallization, inhibit syneresis and encapsulate particulates (Dziezak, 1991); and are found in baked products, bakery fillings, toppings, ice cream products, sherbets, salad dressings and some meat products. Wallingford and Labuza (1983) reported that xanthan gum was more effective than carrageenan, locust bean gum and low methoxy pectin in preventing water loss from a low-fat meat emulsion while Fox et al. (1983) found xanthan gum and carrageenan to stabilize frankfurters in a vinegar pickle. Whiting (1984) noted that alginate or xanthan gums (0.1-0.3%) improved water binding in frankfurters but were detrimental to gel strength. Foegeding and Ramsey (1986), on the other hand, compared the effects of ≤1% iota-carrageenan, kappa-carrageenan, guar gum, locust bean gum, xanthan gum, methylcellulose and a locust bean gum/kappa carrageenan mixture in low-fat (11% to 12%), high moisture meat batters. Methylcellulose decreased yield in low-fat franks, while xanthan and guar gum altered texture profile analysis. Kappa and iota carrageenan appeared to be the most beneficial for holding moisture and increasing hardness, and hedonic scores indicated that low-fat franks with carrageenan were as acceptable as the 27% fat control frankfurters (Figures 5 & 6).

In another application, Huffman and Egbert (1990) incorporated 0.5% carrageenan, 0.375% salt, 0.188% hydrolyzed vegetable protein, and 3.0% water into low-fat (~9%) beef patties and compared them to all-beef patties with 10% or 20% fat. The carrageenan treatment was equal in sensory acceptability and beef flavor to the 20% pattie and more acceptable than the 10% pattie (Figure 7). In addition, consumption of the lower fat treated pattie would result in a reduction of 55 to 60 kcal/100g serving or a caloric decrease of 22% to 23% on an as-eaten basis.

Alginate is widely used as a gelling agent in foods and may also offer potential as a fat replacement when used as a component of a fat substitute/gelling system. The use of

Figure 5



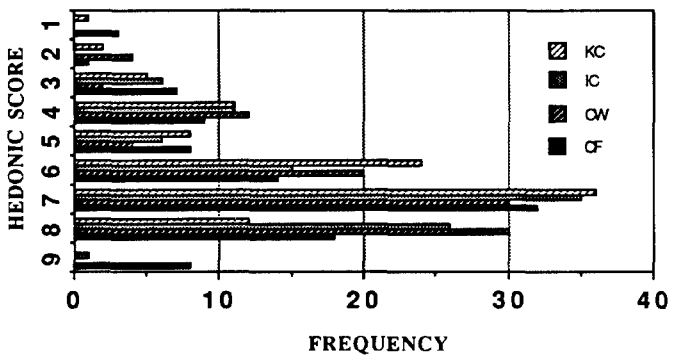
Effect of gum concentration on batter weightloss. All batters were heated to 70°C. CF = control-fat, CW = control-water, IC = iota carrageenan. KC = Kappa carrageenan, XG = xanthan gum.

Foegeding and Ramsey (1986)

sodium alginate and calcium carbonate as a binder for restructured meat has been demonstrated by Means and Schmidt (1986) at levels of 0.8% to 1.2% sodium alginate and 0.144% to 0.216% calcium carbonate combined with 550 ppm of sodium erythorbate. Trout (1989) reported that the optimum concentrations of calcium carbonate and alginate required for minimum discolorate and maximum raw and cooked bind strengths were 0.13% and 0.7%, respectively. Additional work by Clarke et al. (1988) demonstrated that combinations of 0.6% sodium alginate/0.1% calcium carbonate/0.15% lactate in restructured beef increased hardness, penetration and bind values over a range of pH from 4.9 to 5.8 with superior bind scores achieved at pH values of 5.7 to 5.8.

Cellulose-derived ingredients have been tested in formulated meat products. Lin et al. (1988) compared four types of carboxymethyl cellulose (CMC) at 0.25% in low-fat (~15%), high moisture frankfurters and found that all decreased Instron texture profile parameters and softened the franks. In a study of lean beef (5.4% fat) containing 0.5 or 1.0%

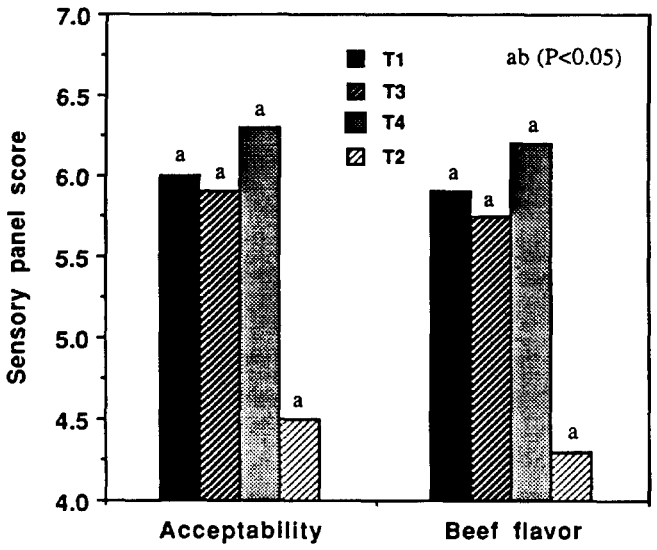
Figure 6



Distribution of hedonic scores (9 = like extremely, 1 dislike extremely) for frankfurters. Frequency indicates the number of times a hedonic score was given during 102 evaluations. CF = control-fat, CW = control-water, IC = iota carrageenan, KC = kappa carrageenan.

Foegeding and Ramsey (1986).

Figure 7



Overall acceptability and beef flavor intensity of ground beef patties. Treatments are: (T1) 20 percent fat product (control) ground through a 1/8-inch (0.32-cm) grinder plate; (T2) 10 percent fat product ground through a 1/8-inch plate; (T3) 10 percent fat product with 0.25 percent salt and 0.125 percent hydrolyzed vegetable protein (HVP) added, finely ground through a 3/16-inch (0.48-cm) grinder plate and; (T4) 10 percent fat product with 3.0 percent water, 0.375 percent salt, 0.188 percent HVP and 0.50 percent carrageenan added, finely ground through a 3/16-inch grinder plate. Bars with different superscripts are significantly different ($P<0.05$).

Huffman and Egbert (1990)

methylcellulose and hydroxypropylmethylcellulose, Hill and Prusa (1988) found these ingredients to increase patty gumminess, decrease Instron compression scores and decrease meat flavor. Todd et al. (1990) evaluated ground pork containing 25% fat with 3.5% and 7.0% cellulose, microcrystalline cellulose and a soluble gum based on the total dietary fiber content of each ingredient. Products containing the gum produced a significant off-flavor and those with cellulose or gum had a distinct graininess/flouriness attribute. Microcrystalline cellulose at 3.5% was comparable to the control for all attributes evaluated.

Carbohydrates, such as starches and flours, have been used in the meat industry to improve cooking yields due to their ability to absorb large amounts of water, reduce formulation costs and serve as cryoprotectants in frozen surimi products, but limited information is available about their use as fat replacements. Odio (1989) evaluated 10 starches or maltodextrins from rice, tapioca, corn, peas, potatoes and oats, and identified modified waxy maize starch (MWMS), tapioca dextrin (TADE) and rice flour (RIFL) to have potential when added (2.5% to 5.0% levels) to frankfurters containing 9% or 15% fat. Low-fat franks containing MWMS, TADE, and RIFL had similar flavor and texture profiles except for a slightly detectable starch flavor at the 9% fat level (Tables 7 & 8). Cooking yields were decreased by 1% to 2% for MWMS and RIFL and 5% for the TADE, but increasing the processing oven relative humidity could make yields equivalent to a regular fat product. Skrede (1989) evaluated cooked Norwegian sausages containing 21.1% fat and 4% levels of potato flour, modified potato starch and wheat, corn or tapioca starch. She reported potato flour to be the best suited starch and tapioca the least after yield and sensory determinations were made. In another study, Berry and Wergin (1990) evaluated the replacement of lean with an 8% modified pregelatinized potato starch gel (3% starch, 5% water) in 4% and 20% fat beef patties. The gel-treated patties had lower sensory flavor and juiciness scores, higher tenderness scores and improved cooking yields of 4% to 6%. They also noted that use of the starch gel may allow a greater removal of fat during cooking.

Carbohydrate based fat substitutes or mixtures of gums, starches and/or proteins appear to offer the most cost effective means of replacing a significant portion of fat in meat products and duplicating the textural and sensory characteristics of animal fat. Much work, however, remains to discover the most appropriate combinations of ingredients and acceptable meat flavor systems for producing low-fat processed meats.

Synthetic Compounds

For new fat substitutes to succeed, they must be technically superior to existing substitutes and offer greater versatility while mimicking the taste, texture and function of fat, but without the calories. Currently, the largest markets for syn-

Table 7. Texture Evaluation Means of the Sensory Profile Panel for Control and 9% Fat Frankfurters with Added Carbohydrates[1].

Texture	*Treatments*		*RIFL*		*TADE*		*MWMS*	
Attribute	*Use levels (%)*	*28CO[2]*	*2.5*	*5.0*	*2.5*	*5.0*	*2.5*	*5.0*
Hardness		5.15	5.15[a]	5.28[a]	4.95[a]	5.17[a]	4.89[a]	4.95[a]
Springiness		7.32[a]	7.08[a]	7.40[a]	7.33[a]	7.52[a]	7.89[b]	8.00[b]
Juiciness		7.45[b]	7.05[ab]	6.83[a]	7.42[b]	7.05[b]	7.08[ab]	6.90[a]

[1] Carbohydrates: RIFL = rice flour, TADE = tapioca dextrin, MWMS = modified waxy maize starch

[2] 28CO = 28% fat control

[a-c] Data in the same row with a common superscript are not different ($P>0.05$)
Data based on a 16-point scale, 0 = not present, 15 = extremely strong

Odio (1989)

Table 8. Texture Evaluation Means of the Sensory Profile Panel for Control and 15% Fat Frankfurters with Added Carbohydrates[1].

Texture	*Treatments*		*RIFL*		*TADE*		*MWMS*	
Attribute	*Use levels (%)*	*28CO*[2]	*2.5*	*5.0*	*2.5*	*5.0*	*2.5*	*5.0*
Hardness		5.15[ab]	5.40[bc]	5.60[c]	5.40[b]	5.02[ab]	4.90[a]	5.15[ac]
Springiness		7.32[a]	7.28[a]	7.95[b]	6.98[a]	7.40[a]	7.78[ab]	8.05[b]
Juiciness		7.45[b]	7.45[b]	7.25[ab]	7.43[b]	7.14[b]	7.21[ab]	6.70[a]

Carbohydrates: RIFL = rice flour, TADE = tapioca dextrin, MWMS = modified waxy maize starch

[2] 28CO = 28% fat control

[a-c] Data in the same row with a common superscript are not different (P>0.05)

Data based on a 15-point scale, 0 = not present, 15 = extremely strong

Odio (1989)

thetic fat substitutes are in the fats and oils sector and amount to over 14 billion pounds/yr. The meat processing industry could also benefit from a new class of fat substitutes, provided that the economics are favorable. Cost estimates for fats and some potential substitutes are: Soybean Oil, $.20-.30/lb; Milk Fat, $1.35/lb; Starches and some Soy Proteins, ~$1.00/lb; Esterified Propoxylated Glycerol (EPG), $1.00-2.00/lb; Simplesse®, $2.00-3.00/lb (Morrison, 1990). Although few synthetic compounds are available for use at the present time, examples of those with the greatest market potential are given in Table 3.

Fat Modification of Processed Meats

Decreasing the fat content and modifying the composition of meat products is accomplished by changing the raw materials through alterations in an animal's genetics or by adjusting the feed composition. Additional changes in fat content and fatty acid composition can be made by reformulating the meat product and substituting less saturated fats or by incorporating a less caloric-dense ingredient in the place of fat.

Modifications in Raw Material

Changes in the lipid component of diets fed to monogastrics, but not so much so for ruminants, have a dramatic effect on the fatty acid composition of a carcass. Pigs fed diets containing 10% to 20% canola oil (St. John et al., 1987), high oleic acid sunflower oil (80% oleic acid) (Rhee et al., 1988), safflower oil, and others (Shackelford et al., 1989) produced carcasses that had a 10% to 40% decrease in the saturated fatty acid ($C_{14:0}$, $C_{16:0}$, and $C_{18:0}$) content of muscle and adipose tissue with a corresponding increase in oleate ($C_{18:1}$). However, modified diets can cause pig carcasses to be more oily, less firm, more susceptible to oxidative rancidity and in some cases less palatable. St. John et al. (1986) produced acceptable reduced-fat frankfurters with 20% less saturated fat by using lean and fat tissues from pigs fed diets containing 10% or 20% canola oil. Using pork tissues from animals fed animal fat, safflower oil, sunflower oil and canola oil, Shackelford et al. (1990) found low-fat, high oleate pork sausage (25% fat) to be more tender and less cohesive. Sausages from swine fed safflower oil and sunflower oil were comparable to control for overall palatability, but sausages from the canola oil treatment scored lower for flavor and palatability. Tissues from the same animals were incorporated into a fermented summer sausage (15% fat) (Shackelford et al., 1990) which received similar scores for sensory and visual characteristics.

Substitution of Animal Fats with Oils

Park et al. (1989) replaced half (7.5%) of the fat in a low-fat (15%) frankfurter with high oleic acid sunflower oil (HOSO) or deodorized menhaden oil and found the fish oil franks to have an undesirable fish flavor. HOSO, however, increased the monounsaturated/saturated fatty acid ratio in beef/pork franks by 468% (Table 9), and increased firmness and springiness but decreased juiciness. In a subsequent study (Park et al., 1990), water was added up to the maximum allowable amount and frankfurters were as acceptable as the 28% fat controls. Marquez et al. (1989) produced franks having 12%, 20% and 29% total fat, but with a 60% substitution of each fat level with peanut oil. The 12% fat franks were less acceptable to consumer panelists, but no sensory differences were found between the 20% and 29% fat levels. Franks with 60% peanut oil substitution also contained less cholesterol.

Modification of the fatty acid composition of low-fat processed meats by substituting raw meat with less saturated fat, or oils with high levels of oleate for a portion of the total fat could significantly improve the nutritional profile of these products. Some sensory differences may be noted depending upon the source of oil, but flavor enhancement with seasonings could enable the production of these products.

Summary

Reducing the total fat content of processed meats with fat replacements is feasible, and in combination with substitution of a portion of the animal fat with oils, significant reductions in caloric content, saturated fats and cholesterol could be achieved. These improvements could result in a new category of products which taste good, have a high degree of nutritional merit and offer the consumer an alternative to traditional processed products.

Table 9. Fatty Acid Compositions for Low-Fat (<18%) Frankfurters Containing Maximum Amounts of HOSO[a] and Regular-Fat (30%) Products.

	Fatty acid(%)[b]										
Product	14:0	16:0	16:1	18:0	18:1	18:2	20:4	Total sat.	Total unsat.	Total monounsat.	M/S ratio[c]
LF - HOSO - BP[d]	0.3	8.5	0.6	5.7	72.3	11.3	1.2	14.5	85.4	72.9	5.03
HF - C - BP[e]	1.1	19.5	2.7	10.6	53.9	11.1	1.2	31.2	68.9	56.6	1.81
LF - HOSO - B[f]	0.3	6.5	0.3	5.3	75.3	11.1	1.3	12.1	88.0	75.6	6.25
HF - C _ B[g]	3.2	25.6	2.4	15.5	46.4	5.5	1.4	44.3	55.7	48.8	1.10
HOSO[h]	—	2.8	—	4.1	87.5	5.6	—	6.9	93.1	87.5	12.68

[a] High-oleic acid sunflower oil
[b] Percentage based on the total peak area
[c] The ratio of total monounsaturated fatty acids to total saturated fatty acids
[d] Low fat maximum HOSO added 40/60 added beef/pork blend
[e] High fat no HOSO added, 40/60 beef/pork blend
[f] Low fat, maximum HOSO added all-beef
[g] High fat, no HOSO added all-beef
[h] High-oleic acid sunflower oil itself

Park et al. (1989)

Considerations for Reformulating Processed Meats

1. Fat contributes flavor, juiciness, a specific mouthfeel and tenderness to meat products (Low-fat products require flavor and textural enhancement).
2. Availability of raw material (Sufficient lean may not be available).
3. Processing yields affect costs (Higher humidities in the smoke house will likely be required for fully cooked products to prevent excessive moisture loss).
4. Nutrient composition and claims can be important (Reduced fat or lower cholesterol claims may be possible).
5. Shelf-life must be considered (Fresh products may spoil more quickly or frozen products may lose more water upon thawing).
6. Microwave heating (Moisture retention is critical for products to be microwaved).

References

Ahmed, P.O.; Miller, M.F.; Lyon, C.E.; Vaughters, H.M.; Reagan, J.O. 1990. Physical and sensory characteristics of low-fat fresh pork sausage processed with various levels of added water. J. Food Sci. 55:625-628.

Anonymous. 1990. Fat substitute update. Food Tech. 44(3):92-97.

Berry, B.W.; Leddy, K.F.; Bodwell, C.E. 1985. Sensory characteristics, shear values and cooking properties of ground beef patties extended with iron- and zinc-fortified soy isolate, concentrate or flour. J. Food Sci. 50:1556-1559.

Berry, B.W.; Wergin, W.P. 1990. Effects of fat level, starch gel usage and freezing rate on various properties of ground beef patties. J. Animal Sci. 68 (Suppl. 1):204-205.

Brown, L.M.; Zayas, J.F. 1990. Corn germ protein flour as an extender in broiled beef patties. J. Food Sci. 55:888-892.

Drake, S.R.; Hinnergardt, L.C.; Kluter, R.A.; Prell, P.A. 1975. Beef patties: The effect of textured soy protein and fat levels on quality and acceptability. J. Food Sci. 40:1065-1067.

Dziezak, J.D. 1991. A focus on gums. Food Tech. 45(3):116-132.

Clarke, A.D.; Sofos, J.N.; Schmidt, G.R. 1988. Influence of varying pH and algin/calcium binders on selected physical and sensory characteristics of structured beef. J. Food Sci. 1266-1277.

Claus, J.R.; Hunt, M.C.; Kastner, C.L. 1989. Effects of substituting added water for fat on the textural, sensory, and processing characteristics of bologna. J. Mus. Foods 1:1-21.

Claus, J.R.; Hunt, M.C.; Kastner, C.L.; Kropf, D.H. 1990. Low-fat, high-added water bologna: Effects of massaging, preblending, and time of addition of water and fat on physical and sensory characteristics. J. Food Sci. 55:338-345.

Foegeding, E.A.; Ramsey, S.R. 1986. Effect of gums on low-fat meat batters. J. Food Sci. 51:33-46.

Fox, J.B.; Ackerman, S.A.; Jenkins, R.K. 1983. Effect of anionic gums on the texture of pickled frankfurters. J. Food Sci. 48:1031-1035.

Gilchrist, C.L. 1987. Influence of fat levels, nonmeat proteins, salt, sodium tripolyphosphate and temperature on the chemical, physical and sensory properties of frankfurter-type sausages. M.S. Thesis. Texas A & M University, College Station, TX.

Hand, L.W.; Hollingsworth, C.A.; Calkins, C.R.; Mandigo, R.W. 1987. Effects of preblending, reduced fat and salt levels on frankfurter characteristics. J. Food Sci. 52:1149-1151.

Hill, S.E.; Prusa, K.J. 1988. Physical and sensory properties of lean ground beef patties containing methylcellulose and hydroxypropylmethyl cellulose. J. Food Qual. 11:331-337.

Hoogenkamp, H. 1989. Low, lean & lite. Meat Processing, October, pp. 48-53.

Huffman, D.L.; Egbert, W.R. 1990. Chemical analysis and sensory evaluation of the developed lean ground beef products. "Advances in Lean Ground Beef Production." Bulletin 606, Alabama Agricultural Experiment Station, Auburn University, Auburn University, Alabama. pp. 22-27.

Lin, K.C.; Keeton, J.T.; Gilchrist, C.L.; Cross, H.L. 1988. Comparisons of carboxymethyl cellulose with differing molecular features in low-fat frankfurters. J. Food Sci. 53:1592-1595.

Marquez, E.J.; Ahmed, E.M.; West, R.L.; Johnson, D.D. 1989. Emulsion stability and sensory quality of beef frankfurters produced at different fat or peanut oil levels. J. Food Sci. 54:867-873.

McGinnis, J.M.; Nestle, M. 1989. The Surgeon General's report on nutrition and health: policy implications and implementation strategies. Am. J. Clin. Nutr. 49:23-28.
Means, W.J.; Schmidt, G.R. 1986. Algin/calcium gel as a raw and cooked binder in structured beef steaks. J. Food Sci. 51:60-65.
Morrison, R.M. 1990. The market for fat substitutes. "Natural Food Review." 13(2):24-30.
Odio, E.M. 1989. Chemical, physical, and sensory characteristics of reduced-fat meat batters and products with added carbohydrates. M.S. Thesis. Texas A & M University, College Station, TX.
Park, J.; Rhee, K.S.; Keeton, J.T.; Rhee, K.C. 1989. Properties of low-fat frankfurters containing monounsaturated and omega-3 polyunsaturated oils. J. Food Sci. 54:500-504.
Park, J.; Rhee, K.S.; Ziprin, Y.A. 1990. Low-fat frankfurters with elevated levels of water and oleic acid. J. Food Sci. 55:871-874.
Putnam, J.J. 1990. Food consumption. "National Food Review." (13(3):1-9.
Reitmeier, C.A.; Prusa, K.J. 1987. Cholesterol content and sensory analysis of ground pork as influenced by fat level and heating. J. Food Sci. 52:916-918.
Reitmeier, C.A.; Prusa, K.J. 1991. Composition, cooking loss, color and compression of ground pork with dry- and wet-milled corn germ meals. J. Food Sci. 56:216-219.
Rhee, K.S.; Ziprin, Y.A.; Ordonez, G.; Bohac, C.E. 1988. Fatty acid profiles of the total lipids and lipid oxidation in pork muscles as affected by canola oil in the animal diet and muscle location. Meat Sci. 23:293.
Rongey, E.H; Bratzler, L.J. 1966. The effect of various binders and meats on the palatability and processing characteristics of bologna. Food Tech. 20:1228.
Savell, J.W.; Branson, R.E.; Cross, H.R.; Stiffler, D.M.; Wise, J.W.; Griffin, D.B.; Smith, G.C. 1987. National Consumer Retail beef Study: Palatability evaluations of beef loin steaks that differed in marbling. J. Food Sci. 52:517-532.
Savell, J.W.; Cross, H.R.; Francis. J.J.; Wise, J.W.; Hale, D.S.; Wilkes, D.L.; Smith, G.C. 1989. National Consumer Retail Beef Study: Interaction of trim level, price and grade on consumer acceptance of beef steaks and roasts. J. Food Qual. 12:251-274.
Savell, J.W.; Cross, H.R.; Hale, D.S.; Beasley, Lisa. 1991. National Beef Market Basket Study. J. Anim. Sci. Submitted.
Shackelford, S.D.; Miller, M.F.; Haydon, K.D.; Reagan, J.O. 1990. Evaluation of the physical, chemical and sensory properties of fermented summer sausage made from high-oleate pork. J. Food Sci. 55:937-941.
Shackelford, S.D.; Miller, M.F.; Haydon, K.D.; Reagan, J.O. 1990. Effects of feeding elevated levels of monounsaturated fats to growing-finishing swine on acceptability of low-fat sausage. J. Food Sci. 55:1497-1500.
Skrede, G. 1989. Comparisons of various types of starch when used in meat sausages. Meat Sci. 25:21-36.
Sofos, J.N.; Allen, C.E. 1977. Effects of lean meat source and levels of fat and soy protein on the properties of wiener-type products. J. Food Sci. 42:875-878.
Sofos, J.N.; Noda, I.; Allen, C.E. 1977. Effects of soy proteins and their levels of incorporation on the properties of wiener-type products. J. Food Sci. 42:879-884.
St. John, L.C.; Buyck, M.J.; Keeton, J.T.; Leu, R.; Smith, S.B. 1986. Sensory and physical attributes of frankfurters with reduced fat and elevated monounsaturated fats. J. Food Sci. 51:1144-1179.
Todd, S.L.; Cunningham, F.E.; Schwenke, J.R.; Goetsch, S.J. 1990. Sensory analysis of fiber formulated ground pork patties. J. Sensory Stud. 5:145-157.
Trout, G.R. 1989. The effect of calcium carbonate and sodium alginate on the color and bind strength of restructured beef steaks. Meat Sci. 25:163-175.
Tye, R.J. 1991. Konjac Flour: Properties and applications. Food Tech. 45(3):82-92.
USDA. 1983. Food Intakes: Individuals in 48 States, Year 1977-78. USDA, Human Nutrition Information Service, Report (NFCS 1977-78) No. I-1.
USDA-FSIS. 1990. Approval of substances for use in the preparation of products. "Code of Federal Regulations," Title 9, Pt. 318.7 and 381.147. Office of Federal Register, National Archives and Records, GSA, Washington, DC.
USDA-FSIS. 1990. Definitions and Standards of Identity of Composition,Subpart G—Cooked Sausage. "Code of Federal Regulations," Title 9, Pt. 319.180. Office of Federal Register, National Archives and Records, GSA, Washington, DC.
Wallingford, L.; Labuza, T.P. 1983. Evaluation of the water binding properties of food hydrocolloids by physical/chemical methods and in a low fat meat emulsion. J. Food Sci. 48:1-5.
Whiting, R.C. 1984. Addition of phosphates, proteins, and gums to reduced-salt frankfurter batters. J. Food Sci. 49:1355-1357.
Ziprin, Y.A.; Rhee, K.S.; Carpenter, Z.L.; Hosteler, R.L.; Terrell, R.N.; Rhee, K.C. 1981. Glandless cottonseed, peanut and soy protein ingredients in ground beef patties: Effects on rancidity and other quality factors. J. Food Sci. 46:58-61.

Discussion

D. Bartholomew: Jimmy, as far as we're leaning up the product and using less fat, what do you suggest we do with the fat now?

J. Keeton: I have a good answer for that. I think that we should sell it to Beef Products, Incorporated. No, I'm serious. I think there are some opportunities. We talked about this. I think there are some opportunities for us to recover, on the short term basis, some of the material that we are currently throwing away into rendering. I think that we also need to be looking at other uses of this material. I think in the long term, if our consumer market dictates leaner raw materials, we will eventually produce leaner raw materials. But, I certainly think that there are technologies, such as B.P.I., that they have available today that can produce an ingredient, in other words, manufacture another ingredient. And this ingredient, my understanding, they could sell more than they can produce right now. So I think that's an alternative. Another possibility is, what do you do with collagen from desinewing, and things like that. There are some other possibilities that we could use collagen as an ingredient, collagen for use for other types of products also. So I don't think we've looked at all the possibilities.

R. Terrell: Jimmy, just one comment. Dale, when you're asked a question about nutritional labeling, why don't you just cite the "policy memo" that you have and let people here know that the USDA policy memo is available and you can follow up that way. It's rather unclear at this point as to all the details that you have to put on a nutritional label. It's also rather unclear as to whether or not the retailer is subject to those same things. If he buys it from an official establishment, it has to be done that way, but if he grinds the meat and makes it in the back of the store, he's basically exempt from Federal Meat Inspection. The other comment I have relates to fat replacers and I have had a little work I've done on the research side of this. What I see us doing here is not terribly creative. I don't want to hurt anybody's feelings, but, we're basically just taking what's available and sticking it in meat and trying to figure out how it works. I did some work for a

client in the East, that I told "You know if you're really going to get to fat replacers, you have to do it on a product-by-product basis, and you should be asking what is the desirable feature and then develop the material." We are going to spend a lot of time and effort re-inventing the wheel on this. If you go back to 1972, to the School Lunch Notice, FNS 219, and if you look in the literature very carefully, of all the work done with soy, you'll find about 50% of the answers that you need to start a research project with. And I'll just point that out. Getting rid of the fat to the beef thing, you have got to remember on that process, you have to have 12% lean in order to call it, I guess "low or low-reduced fat" ground beef, so if you have pure fat, it won't fly in that system. You've got to have at least 12% visible lean in order to meet the regulation.

Keeton: There's an alternate product called partially-defatted chopped beef tissue, and that product is sold overseas, is my understanding. And that's made from 100%, in other words, trimmings that show 100% fat that don't have the 12% lean, and it's an alternate product to that. It is not labeled as the beef product.

Terrell: Well, there was a small organization in Madison, Wisconsin at one time that invented that and had it in all the hot dogs before we came up with a label that said partially-defatted chopped fatty beef or partially-defatted chopped fatty pork. That was a carry-over of low-temperature rendering. But I just pass this along for the students who are interested. You need to go home and ask your professor to get you a copy of the the U.S.D.A. Policy Memo on nutritional labeling of ground beef.

D. Huffman: Bob, I'd like to respond briefly to just one comment. Of course you're correct that these things can be done in the back room of a store and this is, to my mind, very unfortunate. I would discourage anyone from trying to blend carrageenan and the other products in the back room of the store. To the best of my knowledge, it is not being done. I hope it's not being done. We don't want to lose control. We don't want to have products produced that are inferior because we've already seen one problem where some excellent technology that's available today, with the soy protein isolates, has a millstone around its neck because of the problems that you mentioned that we had some 20 years ago.

S. Eilert: I'd like to have you comment on something that I've observed. Perhaps we shouldn't be using, in this low-fat research, fat levels as high as 30% and calling that our control. I don't know what the industry average is right now for frankfurters. I don't know that it would be that high. I also don't know that consumers prefer a 30% fat frankfurter to say a 20% fat. Could you comment on that?

Keeton: Yes, I think if you analyze most of the traditional frankfurter products, they will be 29.5% fat unless they have turkey or some other poultry ingredient in them. I think the reason that we compare these is because this is what consumers are used to buying. If we offer a new product that has a totally different texture and a totally different flavor profile, and call it the same thing, consumers aren't going to be used to that and you may get rejection of the product altogether. For instance, in the example of the McLean. The McLean was trying to duplicate some of the sensory and textural characteristics of our 20% ground beef patties, but yet without the fat in it. So I think that we have to be very careful whenever we do make these comparisons and it might be a good idea to really ask consumers, to make products, and compare over a large consumer segment, what do people really prefer. But I think if we look at the industry and what they're selling, we see what people are buying. Those are good thoughts and good comments of yours.

E. Reynolds: I have a question relative to the labeling of these products from a nutritional standpoint. We've had several references in the conference to the nutritional labeling requirements that are coming down from USDA. And the support of them that Boyle represented, is this not going to pose a major problem for the small processors relative to labeling and the analysis of these products that are required to back this up, not only for these fat-reduced products, but also for those products that are presently being produced under standard procedures?

Keeton: Estes, I think any small producer is going to incur extra expense to do that. I don't see a change forthcoming. I think after 1993, that will be in fact what transpires. Perhaps someone else might like to comment on that, who might be a little closer to the labeling issue than I am. I think it is a good point though.

B. DeMos: Dr. Keeton, you mentioned microcrystalline cellulose as a texturizing agent in either ground or restructured products, and, is it being used strictly as a texturizing agent or does that have other functional properties in those products?

Keeton: What I have observed in the work that's been done in the published literature, it's been used primarily as a texturizing agent rather than a fat substitute. In most cases, things like carboxymethylcellulose and those types of ingredients, soften the product. And so people have used lean meat ingredients and used the carboxymethylcellulose or something like that strictly to soften the product and make it not rubbery or extremely firm.

R. Terrell: I'll comment on carboxymethylcellulose. Nothing new about it. Solka-Floc is, I call it pulpwood, for those of you that haven't looked at cellulose. It binds 10-to-1 on the water and, yes, you have to put it on the label. But if you want to have some fun, get hold of some of that stuff and soak it up. We used to pump hams with it until the government caught us. It does a good job binding water. One thing too, Jimmy, on your list of partial fat replacers, you ought to put on this the impact of changing standards for products such as "reduced-fat ground beef" instead of "low-temperature rendered product." You might want to consider poultry because most of the low-fat products in the marketplace today are mixed species products. It's cheaper to produce them that way than it is to add some of these other things and use 90% lean beef.

Keeton: He's absolutely correct and the poultry products are also using some of these that are already allowed that we don't use in red meat systems. Some of your starches, for instance.