"QUALITY" ATTRIBUTES OF GROUND BEEF PURCHASED
ON THE RETAIL MARKET

by

PATRICIA ANN KENDALL

B. S., Kansas State University, 1969

A MASTER'S THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Foods and Nutrition

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1973

Approved by:

Dorothy L. Harrison
Major Professor

TABLE OF CONTENTS

PAGE

INTRODUCTION

GROUND BEEF is one of the most popular meat items on the retail market. It was served at least once a week by 53.6% of the families in a U.S. survey of food consumption, and accounted for one-fourth of the total quantity of beef purchased (USDA, 1968a). It is also a product that varies highly in fat to lean composition as it may contain up to 30% fat by weight and still be labeled ground beef, chopped beef or hamburger (Federal Registrar, 1972). With such a wide allowance, many retailers are marketing ground beef at three or more fat and price levels, a practice that allows consumers a choice, but also leads to confusion at the meat counter.

Consumer and laboratory taste panel studies have attempted to define the most desirable fat/lean ratio for ground beef. In several studies using consumer taste panels, researchers found that ground beef products containing 15 to 20% fat were more acceptable than products higher (25 to 35%) in lipid content (Glover, 1964; Law et al., 1965; Carpenter and King, 1969; Mize, 1972). Other studies, particularly those that used laboratory taste panels, have shown different results. Nielsen et al. (1967) and Kaiser et al. (1970) reported no significant differences in organoleptic scores for ground beef containing from 13 to 35% fat; whereas, Cole et al. (1960) reported that both a laboratory and a family taste panel rated ground beef containing 15% fat lower in palatability characteristics than ground beef containing 25, 35 or 45% fat.

Cooking losses and their influence on cost per serving in ground beef products varying in fat content are also concerns that have not been well defined for the homemaker. Cole et al. (1960) reported that total and drip cooking losses increased, and volatile losses decreased, as percentage fat in ground beef patties increased from 15 to 45%. Irmiter et al. (1967) and Funk and Boyle (1972) reported similar findings for ground beef cylinders containing from 10 to 30% fat. However, when products contained only 2 to 3% fat, they found that evaporative loss during cooking was so excessive that total cooking loss was greater ($P<0.01$) than it was when ground beef contained 30% fat.

Little information was found on the interrelationships among fat content, cooking losses, other "quality" attributes and cost per cooked serving of ground beef purchased on the retail market. This study, therefore, was designed to investigate palatability, related "quality" factors and cost per serving of three types of ground beef products purchased on the retail market.

REVIEW OF LITERATURE

Purchase and use of ground beef

More than half of the world wide production of meat and meat products consist of beef and veal (USDA, 1968b). Beef was preferred over all other types of meat by more than three-fourths of the families surveyed in a Southern Regional Cooperative study (Mize, 1972). Families ranked selected beef cuts in descending order of preference as follows: beef steak, beef roast, ground beef, beef stew meat. Ground beef was listed as the first choice in a beef product by 17% of the families, and the majority preferred it to lamb, pork roast and fish as a family meat.

Law et al. (1965) reported that ground beef was served in some way two or more times per week by 88% of the families surveyed in Baton

Rouge, Louisiana. Hamburger patties were by far the most common form of ground beef served, with meat balls, meat sauce and meat loaf following in popularity. In other studies, Benson and Ivey (1961) reported that hamburger was purchased regularly by 59% of the families studied, and Baldwin et al. (1972) found that the mean amount of ground beef consumed per person per week was 0.8 lb by those who purchased it from a retail market, and 0.7 lb by those who purchased it from a meat processing plant.

Several researchers have studied motivations in consumer purchases of ground beef. Benson and Ivey (1961) reported that approximately three-fourths of the homemakers surveyed stated that meats purchased regularly were chosen because their families preferred them. Price, the next most common reason given for purchasing certain meat items regularly, was mentioned by only one-fourth of the respondents, and was associated with education level, but not with income. A greater proportion of homemakers with a "high" (13 years or more), than with a lower, education level chose meats on the basis of price.

Woods and Jenkins (1963) reported that versatility and economy were reasons given by almost one-half of their respondents for purchasing ground beef. Cut needed for a special preparation, family preference and ease of preparation were listed as reasons for purchasing ground beef by 25, 16 and 14% of the respondents, respectively. Other reasons listed by more than 5% of the respondents included good taste and preparation time. Baldwin et al. (1972) found no apparent relationship between age categories, number of children, education level or employment and the use of ground beef.

Researchers also have been interested in where and in what form consumers purchase ground beef and other meat products. Law et al. (1965) reported that 79.5% of the respondents in a survey purchased ground beef from the retail food market, 18.9% purchased it from a meat packer or wholesaler and 1.6% used beef processed and packaged by the family. Baldwin et al. (1972) reported findings similar to those of Law et al. (1965), except that approximately 10% more of the respondents in the 1972 study purchased ground beef from the wholesale market, and 10% less purchased it from the retail market than in the 1965 study.

Bensen and Ivey (1961) reported that three out of five families purchased meat in more than one store. Shopping around tended to be associated with education level; a greater number of homemakers with a "high" education (13 years or more) than with a lower education, shopped in more than one store. They noted, however, that age may be a pertinent factor in the above association because the median age of homemakers in the low education group was higher than it was in the "high" education group. Homemakers rated meat quality as the most important reason for purchasing meat at a particular store, and listed convenience and price or economy as other considerations. Both Bensen and Ivey (1961) and Woods and Jenkins (1963) found that the majority of families purchased meat about once a week.

Law et al. (1965) and Mize (1972) reported on the form in which ground beef was purchased. Almost one-half of the respondents in the earlier study (Law et al., 1965) stated that they usually purchased prepackaged ground beef, and one-third stated that they usually had beef ground to order; whereas, 70% of the respondents in the later study

(Mize, 1972) stated that they purchased all ground beef in prepackaged form. Most ground beef was purchased fresh; few homemakers in either study purchased frozen ground beef.

Characteristics looked for in the purchase of ground beef also have been studied. Woods and Jenkins (1963) listed cost, color and texture of lean and USDA grade or inspection stamp as characteristics considered most important by homemakers in the purchase of beef. Law et al. (1965) and Mize (1972) found that color was the most important characteristic looked for when purchasing ground beef. Although only one-sixth of the homemakers surveyed (Mize, 1972) indicated that the amount of fat was a primary concern, the majority of homemakers indicated they disliked the "usual" fat content in ground beef.

When homemakers were asked about perceived quality differences among ground beef products, Kaiser et al. (1970) and Mize (1972) found that 65% and 61% of the homemakers, respectively, believed that hamburger and ground beef were different products. Law et al. (1965) reported that the majority of homemakers surveyed preferred ground chuck and ground round to ground beef for both hamburgers and meat sauce, but purchased ground beef more often than ground round, primarily because of price. Those who purchased ground round or ground chuck instead of ground beef or hamburger usually did so because they wanted less fat, better flavor and more consistent quality.

Specifications for and processing of
ground beef products

Meat products labeled as ground beef, chopped beef or hamburger must consist of chopped fresh and/or frozen beef with or without seasonings. Extenders (such as cereals), binders or water may not be added, and the product may contain no more than 25% trimmed beef cheek meat. Beef fat, as such, may be added to hamburger, but not to products labeled chopped or ground beef; neither may contain more than 30% fat (Federal Registrar, 1972).

The above requirements apply to meat processed both in federally inspected or certified plants and in retail meat departments, although retail meat departments are exempt from the routine inspections common at the plant level (Anonymous, 1971).

Different proportions of muscle and trimmings from the chuck, rib, loin, sirloin, round, shank, brisket, plate and flank are used to produce ground beef products. The products are marketed under various labels, and vary in fat content and price per lb (Anonymous, 1973).

Ground beef is prepared by grinding the meat through plates with openings of various size. Jensen (1949) stated that meat ground through plates with openings measuring 1/8 and 5/64 in. had better binding and lower shrinkage properties, but less desirable flavor than meat ground through plates with larger openings, e.g. 3/16 and 11/32 in. He suggested grinding some of the lean meat through plates with small openings to insure good binding, and using larger-opening plates for the remainder to obtain desirable flavor.

Laboratory methods for measuring fat content of meat

The commercial value of a meat product generally is based on the lean content; therefore, measurement and effective control of fat content, and hence of price, is important to both the meat processor and the consumer (Moreau and Lavoie, 1971). The processor desires to produce a product acceptable to the consumer, but from an economic standpoint, prefers to use as much "fat" as allowed by specifications set forth for the item. The consumer generally is interested in a palatable, nutritionally sound product that is not unduly wasteful. The food or meat scientist is interested in accurate measurements of lipids so that he may study their functions and value in meat and meat products.

Numerous methods have been devised and used to measure or estimate quantity of fat in meat and meat products. The major equipment, solvents, sample weight, and time required for several of the methods are summarized in Table 1.

Method of the Association of Official Analytical Chemists (AOAC). The measurement of crude fat in meat and meat products by ether extraction was first recorded by the Association of Official Agricultural Chemists in 1901 (Kelley et al., 1954). The official method involves anhydrous ethyl or petroleum ether extraction of fat from a dried sample, removal of the solvent by evaporation and measurement of the residue's weight to determine percentage fat (AOAC, 1970). The sample extracted must be free of moisture; otherwise, some water-soluble material may be extracted and reported as fat. Further, it should be dried at temperatures below 125°C to avoid changes that may interfere

Table 1-Summary of selected methods for measuring fat content of meat

Reference	Major equipment	Reagents	Sample size, g	Extraction time
Folch et al. (1951)	Homogenizer or blender	Chloroform Methanol	Varies with system	20-30 min plus 16 hr standing
Kelley et al. (1954)	Centrifuge Babcock bottles	Sulfuric acid Acetic acid	9.0	15-20 min
Salwin et al. (1955)	Centrifuge Babcock bottles	Perchloric-acetic acid	4.5-9.0	20-25 min
Everson et al. (1955)	Steinlight fat tester Distilling flask	Capryl-octyl alcohol	10.0	30 min
Windham (1957)	Steinlight fat tester Blender	Dichlorobenzene	50.0-75.0	30 min
Bligh & Dyer (1959)	Blender Buchner funnel	Chloroform Methanol	100.0	10 min
Wistreich et al. (1960)	Reflux condenser Receiving arm Special flask	Aseotrope-forming fat solvent	10.0	3 hr
Ostrander & Dugan (1961)	Blender Buchner funnel	Chloroform Methanol Zinc acetate	10.0-100.0	15 min
Anderson (1962)	Centrifuge Babcock bottles	"Banco" test reagent, NaOH Methanol, papain	9.0	25-30 min

Table 1-(concluded)

Reference	Major equipment	Reagents	Sample size, g	Extraction time
Lough et al. (1966)	Blender Buchner funnel Distilling flask Rotary evaporator	Chloroform Methanol Methanolic HCl Ethanol, ether	2.0-2.5	4-5 hr
Whalen (1966)	Centrifuge Babcock bottles	Hot HCl Dimethyl sulfoxide	9.0	10 min
Davis et al. (1966)	Reflux condenser Distillation receiver Soxlet extractor Micro vacuum oven	N-butyl ether	10.0	2.0-2.5 hr
Bellis et al. (1967)	Hobart thermal extraction apparatus	--------	56.7	15 min
AOAC (1970)	Oven, Goldfisch or Soxlet apparatus	Pet. or ethyl ether	2.0-2.5	6-18 hr
Moreau & Galhidi (1971)	Centrifuge Babcock bottles	Antifoam A spray NaOH, NaCl	18.0	7 min
Cohen & Kimmelman (1972)	Reflux condenser Distillation receiver Soxlet extractor	Nonane, m-xylene, ethylbenzene or cumene	10.0	15-30 min

with fat extraction (Price, 1971). As extraction time is lengthy, i.e. 4 to 16 hrs, more rapid methods have been devised to provide meat processors with information on the lipid content of their products in the time needed for product "blending and batch correction" (Whalen, 1966).

Rapid methods. Several volumetric methods for measuring lipids in meats have been adapted from Babcock techniques for measurement of fat in dairy products. Those methods usually involve the rapid liberation or extraction of lipids with or without digestion of other components. Kelley et al. (1954) used a mixture of sulfuric and acetic acid, followed by a two-step centrifugation to measure the lipids in a 9-g ground meat sample in 15 to 20 min. Results obtained were related closely to those obtained with ether extraction, provided the meat samples were ground and mixed five times and contained no seasonings or cereals.

Salwin et al. (1955) used a perchloric-acetic acid mixture for more complete digestion of proteins, cereals and spices in meat products than was possible with a mixture of sulfuric and acetic acid. Results with their method were similar to those obtained with the AOAC method, and required approximately 30 min for four measurements. However, the perchloric-acetic acid mixture presented danger of an explosion.

Windham (1957) compared the above two techniques and a technique called the Steinlight method with the official AOAC method and concluded that all three rapid methods were acceptable for plant product control or market survey and screening purposes. With the Steinlight method, lipids in a 50- to 75-g sample were extracted with dichlorobenzene, the extract filtered and the filtrate placed in a special condenser unit to read percentage "fat" using calibration charts.

Anderson et al. (1962) reported a method, based on the principle of the "detergent test" for fat in milk and milk products, that used papain powder, sodium hydroxide, "Banco Fat Test Reagent powder" and methanol to measure the lipids in a 9-g meat sample. The process compared well with AOAC and Salwin's Babcock methods, but required considerable handling and approximately 30 min per extraction.

Whalen (1966) found hot hydrogen chloride and dimethyl sulfoxide (DMSO) particularly effective in rapidly digesting and dissolving the nonfat portions of a 9-g meat sample. He reported excellent phase separation in Babcock bottles, and measurement of lipids in approximately 10 min.

Moreau and Galhidi (1971) reported that percentage "fat" could be obtained in 7 min by heating 18-g homogenized samples in an alkaline medium to separate the fat, and then centrifuging the samples in Babcock bottles. Their data correlated highly with results obtained from ether extraction and Salwin's Babcock method for meat samples with lipid contents of 5 to 50%.

Lipid extraction methods using a polar solvent (chloroform-methanol) have been recommended for more complete extraction of complexed lipid components, particularly phospholipids, than possible with nonpolar solvents such as anhydrous ethyl or petroleum ether (Ostrander and Dugan, 1961; Lough et al., 1966; Hagan et al., 1967). Folch et al. (1951) used chloroform and methanol in the preparation and purification of brain lipids. To extract the lipids, they homogenized the tissue with 2:1 chloroform-methanol (v/v), filtered the homogenate, and freed it of accompanying nonlipid substances by washing with at least five times its volume of water. Bligh and Dyer (1959) and Ostrander and Dugan (1961) modified and shortened the method of Folch et al. (1951) by extracting the purified lipids in a single operation taking approximately 10 min to complete. Lough et al. (1966) noted that the above methods did not remove all the fatty acids and reported the development of a double extraction method in which food samples were extracted with 2:1 chloroform-methanol (v/v), both before and after treatment with 2N hydrochloric acid in methanol. The solvent was removed from the combined extracts and extracted again with chloroform. In all samples, a higher percentage of lipids (0.3 to 2.1% for beef) was found with the chloroform-methanol method than with the AOAC method. The higher values were attributed to a more complete extraction of the bound fatty acids.

Thermal extraction processes for measuring "fat" in meat and meat products have also been developed. Bellis et al. (1967) compared values for percentage fat obtained using a Hobart thermal extraction apparatus with those obtained following the AOAC solvent extraction procedure. The Hobart portable apparatus uses an inverted hot plate, suspended over a 56.7-g (2 oz) doughnut-formed sample, as the thermal source for extraction, and requires approximately 15 min per measurement. Rendered drippings (both meat juices and fat) are collected in a glass tube and percentage fat is measured on a printed scale after adjustments to compensate for volume of meat juices are made. The Hobart thermal extraction process and AOAC method agreed for samples that were ground twice and contained between 15 and 29% crude fat (Bellis et al., 1967).

Simultaneous measurement of fat and moisture content. Since both fat and moisture content are of interest in the development and control of meat products, several methods using azeotrope solvents for extraction and measurement of both fat and moisture have been reported (Everson et al., 1955; Wistreich et al., 1960; Davis et al., 1966; Cohen and Kimmelman, 1972). A variety of solvents, such as capryl-octyl alcohol, nonane, m-xylene or ethylbenzene, were used in the above studies, and results were obtained in 30 min to 3 hrs.

Effect of fat content on selected characteristics of ground beef

Cooking losses. When meats are cooked by dry heat, cooking losses, measured by weight changes between raw and cooked meat, may be separated into dripping and volatile losses. Volatile losses consist primarily of evaporated water, "freed" from the tissue by denaturation and coagulation of proteins, and water-soluble materials such as salts, sarcoplasmic proteins and nonprotein nitrogenous compounds. Aromatic compounds, heat decomposed fat and protein products and fat droplets that have spattered out of the pan also may be included in volatile losses. Drip cooking losses consist primarily of fat, melted out of the meat by heating, but also may include water and nonvolatile water-soluble materials such as salts and sarcoplasmic proteins (Paul, 1972).

Generally, researchers have found that as percentage ether extract in ground beef products increases, drip cooking losses increase and volatile cooking losses decrease; thus causing a variable effect on total cooking losses. Thille (1932) reported greater total cooking losses in "fat" than in "lean" roasts. Cole et al. (1960) studied cooking losses from broiled ground beef patties containing 15, 25, 35 or 45% lipid. They reported that as ether extract from the raw product increased, drip cooking losses increased more than volatile cooking losses decreased, resulting in increased total cooking losses.

Irmiter et al. (1967) and Funk and Boyle (1972) reported cooking loss findings similar to those of Cole et al. (1960) for ground beef products containing from 10 to 30% fat. However, when products contained only 2 to 3% fat, they found that evaporative losses during cooking were so excessive that total cooking losses were greater ($P<0.05$) than they were when ground beef contained 30% fat.

Funk et al. (1968a, 1968b, 1968c) compared the cooking loss data of plain ground beef cylinders reported by Irmiter et al. (1967) with cooking loss data for ground beef cylinders containing 2, 10, 20 or 30% fat, and having added bone, surface fat wrapping or surface connective tissue wrapping. Cooking losses for ground beef cylinders with added bone were not significantly different from those for plain ground beef cylinders. Although, at corresponding fat levels, differences in volatile and drip cooking losses occurred between surface connective tissue wrapped and plain cylinders, general trends were not apparent. However, cylinders with added surface fat wrapping had lower ($P<0.01$) total and volatile losses and higher ($P<0.01$) drip losses than plain ground beef cylinders at the corresponding fat levels. They concluded that during cooking, fat wrapping prevented moisture loss and contributed to drip loss.

Therefore, it appears that several factors affect cooking losses from meat varying in fat content, and subsequent retention of moisture and fat in the cooked product.

Moisture and fat retention in cooked beef. A negative correlation between total moisture and ether extractable material usually occurs within the same muscle of carcasses varying in fat content (Paul, 1965). For raw ground beef products that relationship was reported by Funk and Boyle (1972) and Irmiter et al. (1967) for cylinders containing 2 to 30% lipid. Irmiter et al. (1967) further reported that percentage moisture in cooked ground beef cylinders decreased as ether extract in the raw product increased from 2 to 20%, but that no further decrease in moisture content was found in cylinders containing 30% fat. They concluded that at the 30% level, fat significantly retarded moisture loss during the cooking of ground beef. Similar findings were reported by Funk et al. (1968a, 1968b, 1968c) for ground beef cylinders containing added bone, surface fat wrapping and surface connective tissue wrapping.

The direction percentage "fat" changes with cooking varies depending on the level of "fat" in the raw product. Funk and Boyle (1972) reported that in ground beef products with a lipid content of 30%, percentage ether extract decreased ($P<0.01$) with cooking; however, in products with lipid contents of 3 or 15%, cooking did not significantly affect percentage ether extract. Irmiter et al. (1967) reported that, when calculated on the basis of weight of raw meat, percentage ether extractable material decreased with cooking in ground beef products containing 30% fat, but increased with cooking in products containing 2, 10 or 20% fat. When calculated on a dry weight basis, however, they found no significant difference between crude fat levels of raw and cooked products with a lipid content of 2 or 10% in the raw meat, and a decrease in crude fat levels with cooking for raw products having a lipid content of 20 or 30%.

Woolsey and Paul (1969) reported that a number of researchers, using a variety of muscles, types of meat and methods of cooking, found an increase in the amount of crude fat in "lean" meat after cooking, even when results were converted to a dry basis to allow for moisture loss during cooking. They stated that two possible reasons often given for that increase were: (1) melted fat on the surface of the muscle infiltrated into the tissue during heating and/or (2) heating altered the muscle structure to make fatty materials present in the raw muscle more extractable by ether.

Weir et al. (1962) found that removal of external fat from pork chops before cooking resulted in cooked lean with a fat content close to that of the raw, thus supporting the idea that surface fat infiltrated into muscle during heating. However, Woolsey and Paul (1969) reported that roasted lean semitendinosis muscle increased in percentage fat even when external fat was removed before cooking. Further, they reported that the use of a polar fat solvent (chloroform-methanol), which would be expected to remove fat that might be complexed with protein in the raw tissue, did not make a significant difference in the amount of fat extracted over that measured by ether extraction. They concluded that heating caused protein denaturation and subsequent release of lipid previously complexed with the protein, so the lipid present was more accessible to both polar and nonpolar solvent extraction. They also suggested that the slow increase in temperature at the beginning of the cooking process might have activated enzymes, which in turn released bound fat.

Palatability. Palatability factors usually considered in the evaluation of meat include appearance, color, aroma, flavor, juiciness and tenderness. Appearance and color may be evaluated on either raw or cooked meat; whereas, aroma, flavor, juiciness and tenderness usually are measured only on cooked meat (Paul, 1972). As the ultimate test of palatability is human reaction, both consumer and laboratory panels have been used to study the effect of fat on palatability characteristics.

Color and appearance, important factors in the appeal of fresh meat, are also considerations in the perceived palatability of cooked meat. Law et al. (1965) and Kaiser et al. (1970) reported that consumers preferred ground beef patties containing 15% fat over those containing 25 or 35% fat for visual characteristics such as color of the raw and cooked product, shrinkage and general cooking quality.

The flavor of cooked meat arises from water or fat soluble precursors present in the raw meat. Heating in air promotes reactions among the precursors to produce the flavor and aroma of the cooked meat. Generally, research has indicated that fat may affect meat flavor by producing carbonyl compounds through the oxidation of fatty acids and/or by acting as reservoirs to retain flavor elements that might otherwise be volatilized (Paul, 1972). Hornstein and Crowe (1960, 1961) suggested that the flavor of all lean meat was basically the same, and that fat accounted for much of the flavor differences among different species of animals. Wasserman and Talley (1968) found that Hornstein's and Crowe's hypothesis held true when lamb and pork fat were added to lean veal muscle, but not when beef fat was added to veal muscle. Lawrie (1966), Hertz and Chang (1970) and Hornstein (1970) published general reviews on meat flavor studies and Forss (1969) summarized the role of lipids on flavor.

Researchers who have attempted to determine the level of fat producing the most desirable flavor in ground beef patties have reported variable results. Law et al. (1965), Carpenter and King (1969) and Mize (1972) reported that consumer taste panelists preferred the flavor of patties containing 15% fat to the flavor of patties higher in fat content. However, consumer panelists in a study by Kaiser et al. (1970) and laboratory panelists in studies reported by Cole et al. (1960) and Nielsen et al. (1967) detected no significant differences in the flavor of ground beef patties varying in fat content. Likewise, wives of the family panel in the study of Cole et al. (1960) did not detect significant differences in flavor of ground beef patties containing 15, 25, 35 or 45% fat, but husbands considered the flavor of patties with 15% fat the least desirable.

Tenderness (or texture) is a complex, but important, factor in the acceptance of beef. Intact muscle tenderness is determined principally by the mechanical strength of the muscle fibers and connective tissues, but it also is influenced by the juiciness of the meat, the water holding capacity of the proteins and the amount and distribution of the fat in the muscle (Matz, 1962). With ground beef, grinding should reduce the mechanical strength of muscle fibers and connective tissue so that other properties, such as fat, theoretically could play an even greater role in determining tenderness or texture of ground beef than they do for intact muscle.

Taste panels have varied in their assessment of tenderness of ground beef varying in fat content. Huffman and Powell (1970) used the Allo-Kramer shear press and a laboratory taste panel to measure tenderness in ground beef. Although patties containing 35% fat required less ($P<0.01$) force to shear than patties with 15 or 25% fat, no significant organoleptic differences were found. Kaiser et al. (1970) and Nielsen et al. (1967) also reported that panel members found no significant differences in tenderness among patties varying in fat content; whereas, laboratory and family taste panels in the study of Cole et al. (1960) preferred patties with 25, 35 or 45% fat to those with 15% fat. In other studies, consumer panels used by Carpenter and King (1969) and Mize (1972) considered patties containing 20 or 15% fat, respectively, the most tender.

Juiciness of cooked meat has been separated into two effects: (1) an initial impression of wetness produced by the rapid release of meat fluids during the first few chews, and (2) sustained juiciness, apparently the result of the slow release of serum and the stimulating effect of fat on saliva flow (Weir, 1960).

Although Nielsen et al. (1967), Law et al. (1965), Kaiser et al. (1970) and Mize (1972) reported that taste panels did not detect significant differences in juiciness of ground beef patties varying in fat content, Cole et al. (1960) and Carpenter and King (1969) found that patties containing 15% fat were less juicy than those containing 30 to 35% fat.

The final organoleptic assessment usually made in the ground beef preference studies reviewed was over-all acceptability or "general liking." The majority of studies in which homemakers cooked and served samples to their families (Glover, 1964; Law et al., 1965; Carpenter and King, 1969; Mize, 1972) showed that panel members preferred ground beef lower in fat than did studies in which panel members did not take part in the cooking process (Cole et al., 1960; Nielsen et al., 1967). Further, both Law et al. (1965) and Kaiser et al. (1970) noted that homemakers were more discriminating against increased fat content for visual characteristics associated with the cooking of ground beef (i.e. color before cooking, shrinkage, "general cooking qualities") than their families were towards palatability characteristics (flavor, juiciness and tenderness) associated with the eating quality of ground beef. It appears, therefore, that variations found in over-all acceptability and other palatability characteristics of ground beef varying in fat content may partially be influenced by the manner of measuring acceptance.

MATERIALS AND METHODS

Purchasing and cooking

Packaged ground beef products, of three different formulations available in a store, were selected randomly from the meat display cases of three local retail markets on Mondays from November 6, 1972 through January 15, 1973. After purchase, the nine products were divided randomly into two groups and held in a walk-in refrigerator at 3°C until cooked and evaluated on Tuesday and Wednesday afternoons. Five products were cooked on Tuesday and four on Wednesday.

Three 180-g patties, approximately 2.5 x 7.6 x 8.2 cm were molded from each ground beef product, placed side by side on a wire rack 23 cm in height, set in a shallow pan and cooked in a rotary hearth gas oven maintained at 177°C for 35 min.

Internal temperature, cooking losses, cost per 100-g serving

At the end of the cooking period, the temperature reached in the middle patty on the rack was recorded, and percentage total, volatile and drip cooking losses, based on the weight of the three raw patties, were calculated. Cost per 100-g serving of cooked meat was calculated by dividing the price of 100 g of raw meat by percentage yield (1.0 minus percentage total cooking losses). For objective and sensory evaluation, the crust of each patty was removed. The patty with the recorded internal temperature was evaluated for palatability, and the other two patties were used for objective measurements (Figure 1).

Sensory evaluation

A 7-member laboratory panel selected at random and evaluated 1.9-cm cubes cut from the designated cooked patty, and placed in ceramic casseroles. The cubes were held at a constant low heat (35°C±1°C) on an electric hot tray until sampled by all judges (not more than 30 min).

Flavor, juiciness, texture and over-all acceptability were evaluated using a 5 to 1 scale (Form I, Appendix p. 53). Flavor and over-all acceptability were scored on a desirability scale (5=extremely desirable to 1=undesirable), juiciness was scored on an intensity scale (5=extremely juicy to 1=dry), and texture was scored on a descriptive scale (5=mealy to 1=chewy). Instructions for evaluation were given during preliminary work (Form II, Appendix, p. 54).

Ether extract, total moisture, press fluid, depth of penetration

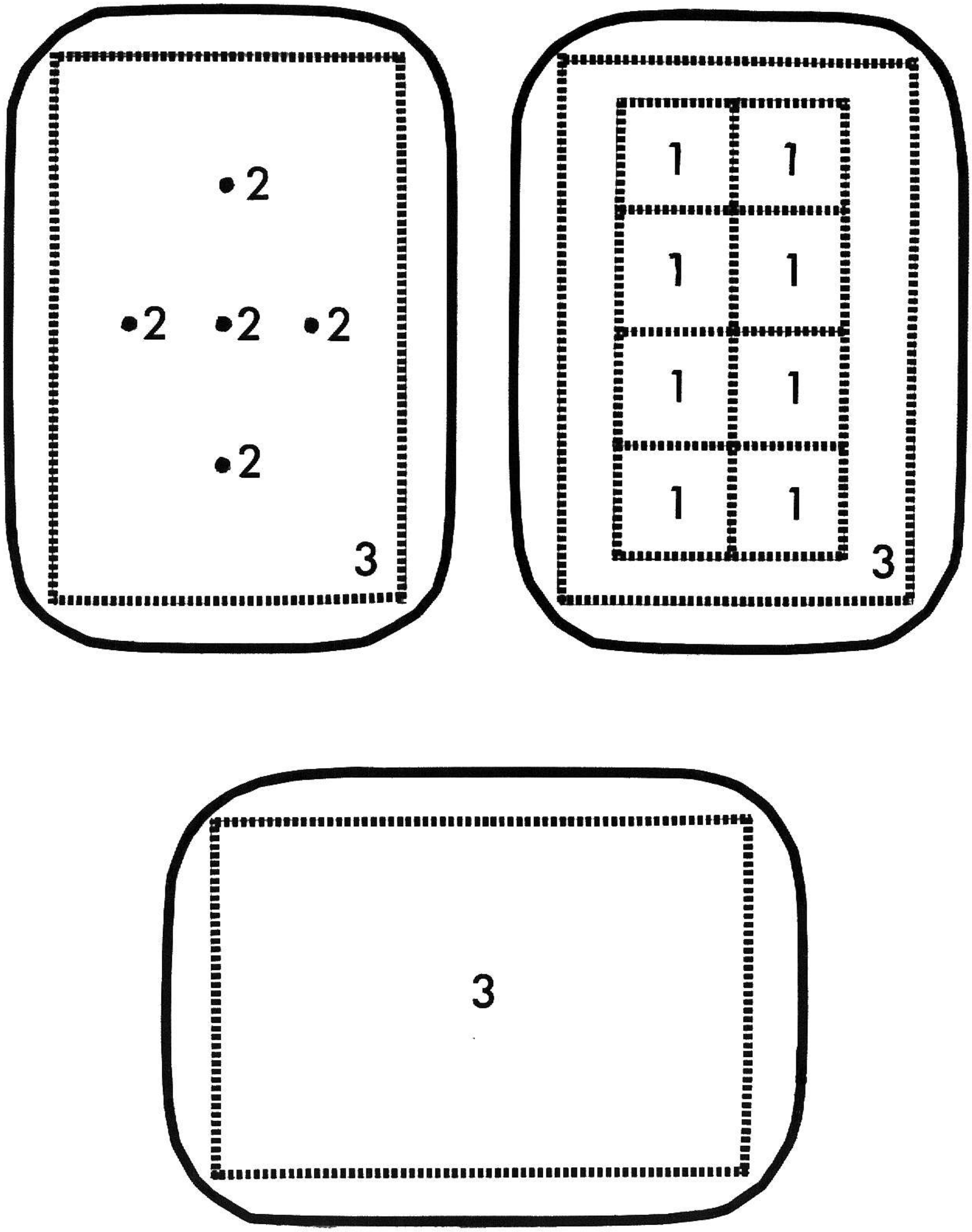
Percentage ether extract in both raw and cooked products was measured according to a modification of the AOAC method (AOAC, 1970). Duplicate 2.5-g samples were dried in 11.5-g teflon coated pans for 60 min at 121°C in a C.W. Brabender Semi-automatic Rapid Moisture Tester. Dried

Fig. 1-Plan for sampling ground beef patties

1—1.9-cm cubes for palatability samples

2—Places where depth of penetration readings were taken

3—Meat that was ground and used for determination of ether extract, total moisture and press fluid


2
2
2
2
2
3
1
1
1
1
1
1
1
1
3
3

samples were rolled in Whatman No. 5 filter paper and transferred to extraction thimbles. Pans used for drying were rinsed with the petroleum ether used in the extraction process so as to include lipid lost during drying. Samples were extracted for 16 hr on a Goldfisch extraction apparatus, the ether was evaporated and the percentage ether extract was calculated.

Percentage total moisture (TM) for each product was determined by drying duplicate 10-g samples of ground, cooked meat in a C.W. Brabender Semi-automatic Rapid Moisture Tester for 60 min at 121°C.

Press fluid from each product was measured on duplicate 25-g samples of ground, cooked meat packed in a cheesecloth-lined (2 layers, 14.5 cm diam) cylinder of a Carver Laboratory Press. The sample was divided roughly into thirds, and packed in the cylinder by alternating the meat with four circles (5.5 cm) of Whatman No. 1 filter paper. The packed cylinder was pressed following a standardized 15-min time-pressure schedule with a maximum pressure of 4,000 psig. The expressed fluid was poured into centrifuge tubes graduated in 0.1 ml, capped with aluminum foil, and placed in a refrigerator until the following day when the volume of total press fluid, serum, fat and solids was read.

The depth (mm) of penetration into one crustless patty from each product was measured with a Universal Precision Penetrometer at the 5 locations shown in Figure 1. Readings obtained from allowing the weight of the penetrometer's cone (150 g) to drop into the meat for 5 sec at each location were averaged to determine the depth of penetration.

Statistical analyses

Data for each measurement used to evaluate the ground beef products were analyzed by analysis of variance:

Source of variation	d/f
Type of product (P)	2
Store (S)	2
Week (W)	5
P X S	4
P X W	10
S X W	10
Error	20
Total	53

For each source of variation for which the F-value was significant, least significant difference at the 5% level of probability was calculated. Bartlett's test for homogeneity of variance was used to study the variation among weeks for a given product; also, Bartlett's test was used to estimate variance among the nine product-store combinations. A regression equation was derived to study the relationship between percentage yield of cooked ground beef and the percentage lipid in the raw meat.

RESULTS AND DISCUSSION

Product label and price differences among stores

The labeling and pricing of the nine products evaluated are presented in Table 2. The three stores whose products were studied represented a state chain (store A), a local chain (store B) and a local Independent Grocers' Association (IGA) affiliate (store C). Products 1, 2 and 3 refer to the lowest, medium and highest priced ground beef products, respectively, that were available at each store. With the exception of

Table 2-Product labeling and mean price per lb

Ground beef products	Store A State chain	Store B Local chain	Store C Local IGA	Tri-store mean price per lb
1	Regular	Regular	Regular	
	Approx. 73% lean	70-75% lean	-----	
Mean price per lb	$0.70	$0.70	$0.74	$0.71
2	Lean	Lean	Ground chuck	
	Approx. 80% lean	75-80% lean	Not less than 90% lean	
Mean price per lb	$0.80	$0.80	$0.96	$0.85
3	"Diet" lean	Extra lean	Ground round	
	Approx. 88% lean	80-85% lean	Not less than 90% lean	
Mean price per lb	$1.00	$1.00	$1.06	$1.02
Store mean price per lb	$0.83	$0.83	$0.92	

products 2 and 3 from store C, an increase in price per lb between any two ground beef products was accompanied by an increase in the labeled percentage lean.

The stores differed slightly in the labeling and pricing given each of their products. Stores A and B used descriptive and percentage lean statements to identify the type of product. Store C did not label percentage lean in its regular ground beef product (1C) and labeled products 2 and 3 according to primal cut (chuck and round) and percentage lean. Products from store C averaged 4, 16 and 6 cents per lb higher in price than correspondingly numbered products from stores A or B.

Percentage ether extract

Mean values for percentage ether extract (lipid) in raw products showed that two stores (B and C) stayed within federal regulations and their own labeling statements concerning the fat content of all three products (Figure 2). However, mean lipid values for products 1 and 2 from store A (1A and 2A) averaged 3.8 and 6.8%, respectively, above labeled approximate percentage non-lean, and 1A averaged 0.8% above federal regulations for the maximum amount of fat allowable in ground beef (30%).

Mean values for objective and subjective measurements attributable to products (all three stores combined) and to stores (all three products from one store combined) are given in Table 3. As product number and price per lb increased, percentage ether extract in both raw and cooked products decreased ($P<0.05$). However, differences in ether extractable material between products 1 and 3 were not as great for cooked as for raw

Fig. 2-Labeled non-lean and percentage ether extract (lipids) in raw and cooked products.

THIS BOOK CONTAINS NUMEROUS PAGES WITH DIAGRAMS THAT ARE CROOKED COMPARED TO THE REST OF THE INFORMATION ON THE PAGE.

THIS IS AS RECEIVED FROM CUSTOMER.

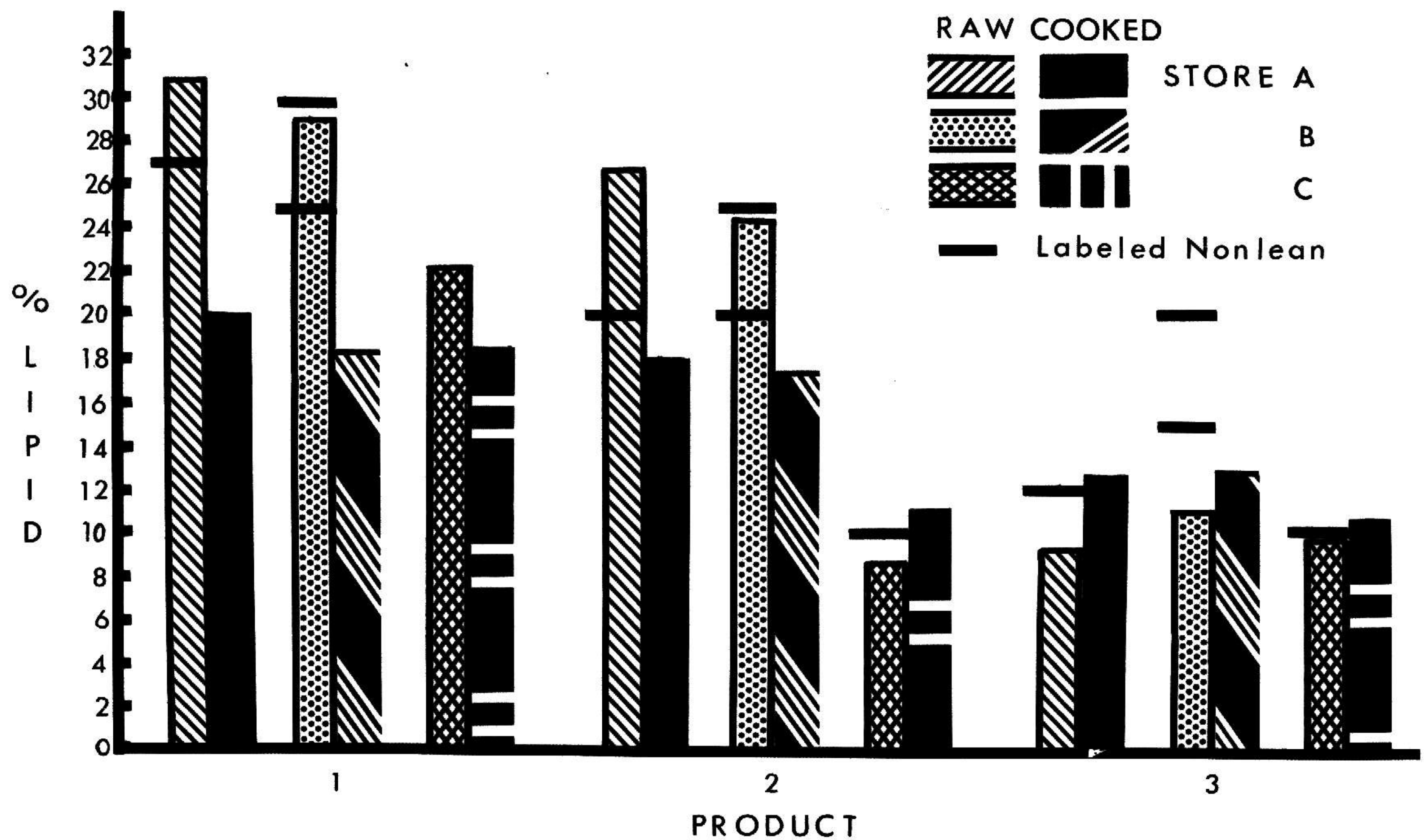

RAW COOKED
STORE A
B
C
Labeled Nonlean
% LIPID
32
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
1
2
3
PRODUCT

Table 3-Means, significance of F-ratios and LSD attributable to products and stores for objective and subjective measurements

Measurement	Product[a]			Significance of F	LSD	Store[b]			Significance of F	LSD
	1	2	3			A	B	C		
Ether extract, %										
Raw meat	27.4	20.0	10.2	***	2.3	22.4	21.6	13.6	***	2.3
Cooked meat	19.0	15.6	12.1	***	1.8	16.9	16.2	13.4	**	1.8
Cooking losses, %										
Total	29.9	25.5	20.4	***	2.1	27.1	27.3	21.3	***	2.1
Volatile	16.5	16.5	17.6	*	1.0	16.7	17.0	16.8	ns	---
Drip	12.9	8.6	2.5	***	1.7	10.0	10.0	4.1	***	1.7
Cost/100-g serving, cents	22.4	25.3	28.2	***	0.7	25.1	25.1	25.7	ns	---
Internal temp., °C	69.9	68.3	66.2	**	2.1	69.3	68.3	66.8	ns	---
Total moisture, %	56.5	60.1	62.7	***	1.8	58.5	59.0	61.7	**	1.8
Press fluid, ml/25 g										
Total	7.2	7.4	7.1	ns	---	7.6	7.0	7.1	**	0.3
Serum	4.5	5.0	5.3	*	0.6	5.0	4.6	5.1	ns	---
Fat	2.0	1.6	0.9	***	0.4	1.9	1.4	1.2	**	0.4
Solids	0.7	0.9	0.9	ns	---	0.6	1.0	0.9	ns	---

Table 3-(concluded)

Measurement	Product[a] 1	Product[a] 2	Product[a] 3	Significance of F	LSD	Store[b] A	Store[b] B	Store[b] C	Significance of F	LSD
Penetration, mm	13.5	13.2	12.2	ns	---	12.3	13.3	13.2	ns	---
Sensory scores, 1-5										
Flavor[c]	3.3	3.2	2.9	ns	---	3.0	3.3	3.2	ns	---
Texture[d]	3.0	3.1	3.5	ns	---	3.1	3.2	3.3	ns	---
Juiciness[e]	3.4	3.2	3.0	ns	---	3.1	3.3	3.2	ns	---
Over-all acceptability[c]	3.2	3.1	3.0	ns	---	3.0	3.2	3.1	ns	---

[a]Values for lowest-priced (1), medium-priced (2), and highest-priced (3) products from all stores combined

[b]Values for all products from state chain (A), local chain (B), and local IGA (C) combined

LSD, least significant difference at 5% level

[c]Range, 5=extremely desirable to 1=undesirable

[d]Range, 5=mealy to 1=chewy

[e]Range, 5=extremely juicy to 1=dry

$*P<0.05$; $**P<0.01$; $***P<0.001$

ns, not significant

meat, because percentage ether extract was less (4 to 11%) for cooked than for raw products 1 and 2A, 1 and 2B and 1C and slightly greater (1 to 3%) for cooked than for raw products 2 and 3C, 3A and 3B (Figure 2, Table 3).

Product 3 contained more ($P<0.05$) moisture and had greater ($P<0.05$) volatile losses, but less ($P<0.05$) drip cooking losses than products 1 and 2 (Table 3). This may account, partially, for the small increase in ether extract of the cooked product. Irmiter et al. (1967) and Funk et al. (1968a, 1968b, 1968c) also found that percentage ether extract decreased with cooking in ground beef containing 30% lipid and increased with cooking in ground beef with 3 to 20% lipid.

Woolsey and Paul (1969) reported that percentage crude fat in "lean" intact muscle often was higher after cooking than before cooking, even when results were reported on a dry weight basis. They also found that neither removal of an external fat layer, nor use of a polar fat solvent (chloroform-methanol) in place of ether, made a significant difference in the amount of fat extracted from raw and cooked lean semitendinosis muscle. They concluded that, under the conditions of their study, heating caused denaturation of protein and subsequent release of lipid previously complexed with protein so that lipid present was more accessible to both polar and nonpolar solvent extraction. They also suggested the possibility that the slow increase in temperature at the beginning of the cooking process activated enzymes, which in turn released bound fat.

For both raw and cooked products, percentage ether extract from store C products averaged lower ($P<0.05$) than that from either store A or store B products (Table 3). Significant product x store interaction occurred for percentage ether extract in raw products (Table 4). Percentage ether extract was lower (P<0.05) in regular ground beef from store C (1C) than in regular ground beef from store A or B (1A, 1B), or in lean ground beef from store A (2A). Also, product 2 from store C (ground chuck) averaged lower (P<0.05) in ether extractable material than product 2 from store A or B (ground lean), and was similar in ether extract to product 3 from all stores. Product x store interaction was not significant for ether extract in cooked products.

Cooking losses and cost per serving

As product number and price per lb increased, total and drip cooking losses decreased (P<0.05). Volatile cooking losses, however, were greater (P<0.05) for product 3 than for products 1 and 2 (Table 3). Cole et al. (1960) and Irmiter et al. (1967) reported similar trends for cooking losses from ground beef with lipid contents of 10 to 30%. Total and drip cooking losses also were greater (P<0.05) for both store A and store B products than for store C products. Mean values for volatile losses varied little among stores (Table 3).

Significant (P<0.05) product x store interactions for total and drip cooking losses were similar to product x store interaction for ether extract in raw products (Table 4). 2C (regular) had less (P<0.05) total and drip cooking losses than 1A or 1B (regular) and less (P<0.05) drip cooking loss than 2A or 2B (ground lean). Also, total and drip cooking losses from 2C (ground chuck) were less (P<0.05) than those from 2A or 2B (ground lean) and were similar to those of 3A, 3B or 3C ("diet" lean, extra lean, ground round). Product x store interaction for volatile losses was not significant.

Table 4-Significant product x store interactions

Measurement	Product	Store A	Store B	Store C	Significance of F	LSD
Ether extract, raw meat, %	1	30.8^{a}	29.1^{a}	22.1^{c}	**	4.0
	2	26.8^{ab}	24.4^{bc}	8.8^{d}		
	3	9.4^{d}	11.3^{d}	9.9^{d}		
Total cooking losses, %	1	32.1^{a}	31.4^{a}	26.1^{b}	**	3.7
	2	28.6^{ab}	29.6^{ab}	18.1^{c}		
	3	20.4^{c}	20.8^{c}	19.8^{c}		
Drip cooking losses, %	1	15.3^{a}	15.3^{a}	8.3^{c}	***	3.0
	2	12.0^{b}	11.7^{b}	2.0^{d}		
	3	2.6^{d}	2.9^{d}	2.1^{d}		

Product 1, regular (lowest-priced)
2, lean, ground chuck (medium-priced)
3, "diet" lean, extra lean, ground round (highest-priced)

Store A, state chain
B, local chain
C, local IGA

LSD, least significant difference at the 5% level

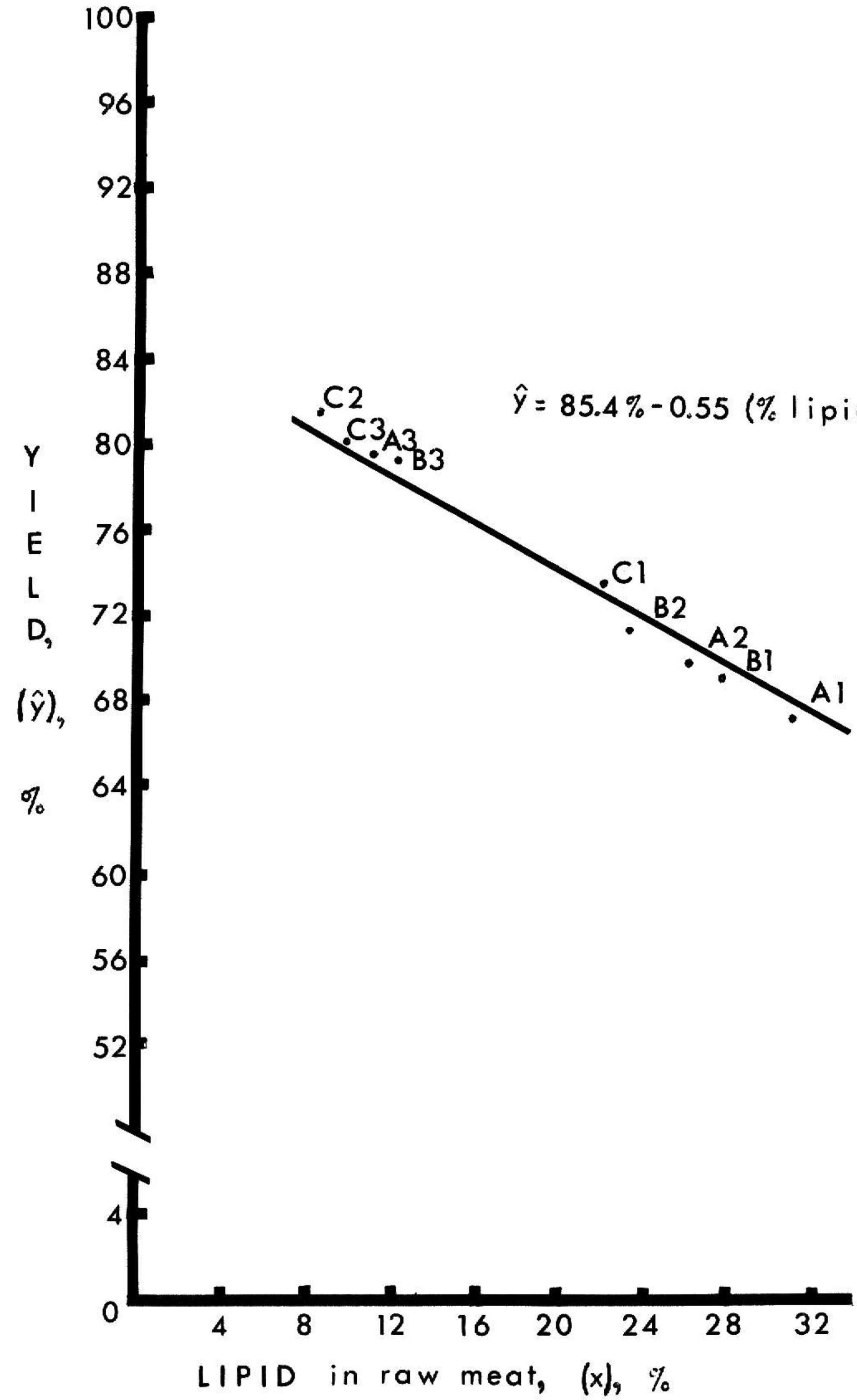
^{a,b,c,d}Means bearing the same superscripts are not significantly different at the 5% level

**$P<0.01$; ***$P<0.001$

Although total cooking losses were less ($P<0.05$) for higher-priced, leaner products than for lower-priced, higher-lipid products, the increases in price per lb for the higher-priced products were such that cost per 100-g serving of cooked meat increased ($P<0.05$) as product number and price per lb increased (Tables 2 and 3). Store C products cost an average of 9 cents more per lb (Table 2), but had 5.8 and 6.0% lower total cooking losses (Table 3) than store A or store B products, so the cost per 100 g of cooked meat did not vary significantly among stores (Table 3). Product x store interaction for cost per 100-g serving of cooked meat was not significant.

A regression equation (Figure 3, $\hat{y} = \alpha - bx$) was derived to compare percentage yield of cooked meat to percentage ether extract (lipid) in raw meat. The equation was based on 54 observations in this study and 36 additional observations from stores A and B. In the equation, $\hat{y}$ is the predicted percentage yield of cooked meat, given x (percentage ether extract (lipid) in the raw meat). The slope of the regression line (b) was computed by multiplying the correlation coefficient between x and y ($r_{xy} = 0.838$) by the standard deviation of y ($\sigma y = 5.88$) over the standard deviation of x ($\sigma x = 8.89$); $r_{xy}\left(\frac{\sigma y}{\sigma x}\right)$. The constant, α, was computed from the equation $\alpha = \bar{y} - b\bar{x}$ (Snedecor, 1956). Percentage yield ($\hat{y}$) from modified broiled ground beef patties equaled 85.4 (α) minus 0.55 (b) of percentage lipid (x); $\hat{y} = 85.4 - 0.55x$. The standard error of estimate for the equation is 3.2, i.e., 68% of the y's would be within plus or minus 3.2 percentage points of the predicted value. The proportion of the variance of yield accounted for by its association with percentage ether extract (lipid) is 0.70 (r^2). Assuming cooking conditions are

Fig. 3-Regression equation for percentage yield vs percentage ether extract (lipid) in raw meat.


100
96
92
88
84
80
76
72
68
64
60
56
52
4
0
YIELD, ($\hat{y}$), %
$\hat{y}$ = 85.4% - 0.55 (% lipid)
C2
C3
A3
B3
C1
B2
A2
B1
A1
4
8
12
16
20
24
28
32
LIPID in raw meat, (x), %

similar to those of this study, the regression line may be used to calculate the cost per lb, or per serving, of cooked meat given the percentage lipid and price per lb for the raw meat. For example, a matrix presented in Table 5 illustrates the cost of a lb of cooked ground beef at several levels of lipid and prices per lb.

Internal temperature, total moisture, press fluid, depth of penetration

After 35 min cooking at 177°C, the internal temperature was higher ($P<0.05$) for products 1 (27.4% lipid) and 2 (20.0% lipid), than for product 3 (10.2% lipid), Table 3. This agrees with findings of Irmiter et al. (1967) and Funk and Boyle (1972) that products with the lowest lipid content, in ground beef cylinders containing from 2 to 30% lipid, required the longest time to reach 80°C. Differences in internal temperature attributable to stores were not significant.

As expected, percentage total moisture in cooked products increased ($P<0.05$) as product number increased, indicating that total moisture was inversely related to lipid content. Also, products from store C were higher ($P<0.05$) in total moisture than products from store A or store B (Table 3).

Total press fluid did not vary significantly among products; however, mean total press fluid was higher ($P<0.05$) for store A products than for store B or store C products (Table 3). During standing, press fluid separated into fat, serum and solids. Press fluid from the lowest-priced, highest-lipid product (product 1) contained less serum and more separable fat than press fluid from either of the other two products. In addition, press fluid from product 2 contained more ($P<0.05$) fat than

Table 5-Cost per lb of cooked ground beef[a] at selected prices and percentages of lipid for raw meat

Price per lb, $, raw meat	Lipid in raw ground beef, %					
	5	10	15	20	25	30
$0.60	$0.73	$0.75	$0.78	$0.81	$0.84	$0.87
0.65	0.79	0.81	0.84	0.87	0.91	0.95
0.70	0.85	0.88	0.91	0.94	0.98	1.02
0.75	0.91	0.94	0.97	1.01	1.05	1.09
0.80	0.97	1.00	1.04	1.08	1.12	1.16
0.85	1.03	1.06	1.10	1.14	1.19	1.24
0.90	1.09	1.13	1.17	1.21	1.26	1.31
0.95	1.15	1.19	1.23	1.28	1.33	1.38
1.00	1.21	1.25	1.30	1.35	1.40	1.45
1.05	1.27	1.31	1.36	1.41	1.47	1.53
1.10	1.33	1.38	1.43	1.48	1.54	1.60
1.15	1.39	1.44	1.49	1.55	1.61	1.67
1.20	1.45	1.50	1.56	1.61	1.68	1.74
1.25	1.51	1.56	1.62	1.68	1.75	1.82
1.30	1.57	1.63	1.69	1.75	1.82	1.89
1.35	1.63	1.69	1.75	1.82	1.89	1.96
1.40	1.69	1.75	1.82	1.88	1.96	2.04
1.45	1.75	1.82	1.88	1.95	2.03	2.11
1.50	1.81	1.88	1.95	2.02	2.10	2.18

[a]Based on the equation, $\hat{y} = 85.4 - 0.55x$, when $\hat{y}$ = percentage yield of cooked meat and x = percentage lipid in the raw meat.

$$\text{Cost per 100 g of cooked meat} = \frac{\text{cost per lb of cooked meat}}{4.54}$$

that from product 3. The amount of serum in press fluids did not vary among stores, but more ($P<0.05$) separable fat was found in press fluids from store A products than in that from store B or store C products. The amount of solids in press fluids did not vary significantly among products or stores (Table 3).

Depth of penetration into cooked meat by a cone (weight, 150 g) on the Universal Precision Penetrometer did not vary significantly among products or stores (Table 3).

Sensory evaluation

Scores for flavor, juiciness, texture and over-all acceptability did not vary significantly among products or stores (Table 3). The two lower-priced, higher-lipid products (1 and 2) rated slightly higher for flavor, juiciness and over-all acceptability, and were considered slightly more chewy than the highest-priced, lowest-lipid product (3). Palatability data for this study agree with laboratory taste panel data reported by Nielsen et al. (1967) and Huffman and Powell (1970), and with consumer taste panel data reported by Kaiser et al. (1970) for ground beef varying in fat content from 13 to 35%. However, in other consumer taste panel studies (Glover, 1964; Law et al., 1965; Carpenter and King, 1969; Mize, 1972) panelists preferred ground beef products containing 15 to 20% lipid to products with higher lipid contents (25 to 35%). The fact that laboratory panels do not take part in the cooking of the patties, and therefore are not influenced by observations of drip and spattering losses, might partially explain differences in acceptance between laboratory and some consumer taste panel data.

Variation among weeks, week x product interactions and week x store interactions

Analysis of variance indicated that, in general, the ground beef products were similar from week-to-week. Significant differences ($P<0.05$) attributable to the week in which products were purchased occurred only for volatile cooking losses, total press fluid and solids in the press fluid, and could not be explained.

Significant interactions for weeks x products did not occur for any measurement. Significant interactions for weeks x stores occurred only for drip cooking losses (Table 6). Store C products had less ($P<0.05$) drip cooking loss than store A products each week except week 2, and less ($P<0.05$) drip cooking loss than store B products each week except weeks 4 and 6.

Variance among products

Law et al. (1965) reported that consumers in a survey stated that they consistently purchased "ground round" and "ground chuck" because they could be assured of greater uniformity than if they purchased "ground beef." In this study variance among the nine product-store combinations was estimated for each measurement by subjecting data to Bartlett's test for homogeneity of variance. Variances for the four measurements that differed ($P<0.05$) among the nine product-store combinations are given in Table 7.

Variances for percentage drip cooking losses were greatest ($P<0.05$) for products 1 and 2 (regular and lean) from stores A and B, less ($P<0.05$) for products 1C, 3A and 3B (regular, "diet" lean, extra lean),

Table 6-Week x store interaction for drip cooking losses

Week	Store A	Store B	Store C	Significance of F	LSD
1	14.4[a]	8.7[cde]	4.1[fg]	*	4.3
2	7.8[cdef]	13.8[ab]	4.3[fg]		
3	9.6[bcd]	10.3[abcd]	4.0[fg]		
4	10.3[abcd]	7.7[cdef]	4.9[efg]		
5	7.5[def]	11.9[abc]	3.2[g]		
6	10.3[abcd]	7.4[defg]	4.3[fg]		

Store A, state chain; B, local chain; C, local IGA

LSD, least significant difference at the 5% level

*$P<0.05$

[a,b,c,d,e,f,g]Means with the same superscripts are not significantly different at the 5% level of probability

Table 7-Variances that differed ($P<0.05$) among product-store combinations

Measurement	Product-store	Variance	Measurement	Product-store	Variance
Drip cooking losses, %	1B	20.52^{a}	Fat in press fluid, ml/25g	2B	1.25^{a}
	2B	17.31^{a}		1C	0.53^{ab}
	1A	14.04^{a}		3A	0.51^{ab}
	2A	12.35^{a}		3B	0.50^{ab}
	1C	2.76^{b}		1B	0.29^{abc}
	3A	1.52^{b}		1A	0.14^{bc}
	3B	1.52^{b}		2A	0.11^{c}
	2C	0.41^{c}		3C	0.09^{c}
	3C	0.21^{c}		2C	0.08^{c}
Flavor, 1-5	3A	0.77^{a}	Over-all acceptability, 1-5	3A	1.00^{a}
	3C	0.36^{ab}		2B	0.40^{ab}
	2B	0.22^{ab}		2A	0.18^{bc}
	2A	0.13^{bc}		3C	0.10^{bc}
	3B	0.12^{bc}		1A	0.09^{c}
	1B	0.09^{bc}		3B	0.08^{c}
	2C	0.09^{bc}		1B	0.07^{c}
	1C	0.07^{c}		1C	0.05^{c}
	1A	0.04^{c}		2C	0.05^{c}

Product-store 1A, regular from state chain
1B, regular from local chain
1C, regular from local IGA
2A, lean from state chain
2B, lean from local chain
2C, ground chuck from local IGA
3A, "diet" lean from state chain
3B, extra lean from local chain
3C, ground round from local IGA

[a,b,c]Variances in the same vertical row bearing the same superscripts are not significantly different ($P<0.05$)

and least ($P<0.05$) for products 2C and 3C (ground chuck and ground round). Comparison of variances (Table 7) with mean values for percentage drip cooking losses (Table 3) indicated that product-store combinations with the lowest drip cooking losses had the least amount of variance.

Variances for fat in press fluid also differed ($P<0.05$) among product-store combinations (Table 7). Variance was greatest for product 2B, but that variance was not significantly greater than variances for 1C, 3A, 3B or 1B. Product-store combinations 2C, 3C and 2A varied the least for fat in press fluid, but not significantly less than products 1A or 1B.

Variances for flavor and over-all acceptability scores were greatest for product 3A. Flavor scores varied least for product 1 from stores A and C, and over-all acceptability scores varied least for product 1 from all stores and products 2C and 3B.

SUMMARY AND CONCLUSIONS

PACKAGED GROUND BEEF products with three different ratios of fat/lean available in a store, were selected randomly from meat display cases of three local retail markets on six Mondays. Products were randomized for cooking and evaluation on Tuesdays and Wednesdays. Patties (180 g each) were cooked by modified broiling at 177°C for 35 min and evaluated for cooking losses, palatability and related "quality" factors and cost per 100-g serving.

As price of the ground beef products increased, percentage ether extract (lipid), in both raw and cooked meat, decreased ($P<0.05$) and percentage total moisture in cooked meat increased ($P<0.05$). Total and drip cooking losses decreased ($P<0.05$) with decreasing lipid in raw meat. Percentage yield for cooked meat equaled 85.4 minus 0.55 of the percentage ether extract (lipid) in the raw meat. As percentage lipid decreased, the decrease in total cooking losses was not great enough to compensate for the increase in price per lb; therefore, the cost per 100-g serving of cooked meat increased ($P<0.05$) with decreasing lipid content.

Volatile losses were greater ($P<0.05$) and internal temperature lower ($P<0.05$) for the leanest product than for the other two products. Total press fluid and depth of penetration by a 150-g cone did not vary significantly among products, but as lipid content decreased, press fluid contained more ($P<0.05$) serum and less ($P<0.05$) fat. Differences among products in flavor, juiciness, texture and over-all acceptability, as judged by a 7-member laboratory taste panel, were not significant.

Under the conditions of this study, it was concluded that:

1. Ground beef that contains 10 to 20% lipid has less cooking loss than ground beef that contains 25 to 30% lipid.
2. In general, percentage ether extract (lipid) decreases with broiling when raw ground beef contains 20 to 30% lipid, and increases with broiling when the raw meat contains less than 12% lipid; therefore, the difference in lipid content between the above two classifications of ground beef products is not as great for broiled as for the raw meat.
3. At prices less than $1.30 per lb for raw ground beef, cost per lb and per serving of cooked meat is less for lower-priced, higher-lipid products (decreasing in increments of $0.10 per lb and increasing in

increments of 10% lipid), than for higher-priced, leaner products. For example, the cost of a cooked lb of ground beef is $0.04 less for raw ground beef priced at $0.90 per lb with a lipid content of 30%, than for raw ground beef priced at $1.00 per lb with a 20% lipid content.

4. The ratio of fat/lean had no significant effect on the palatability of the ground beef products.

REFERENCES

Anderson, B.B., Robinson, L.L. and Hodgkins, J.E. 1962. The "Banco" test: a rapid method for fat in meat and edible meat products. J. Assoc. Offic. Agr. Chem. 45: 13.

Anonymous. 1971. A close look at hamburger. Consumer Reports. 36: 478.

Anonymous. 1973. The meat of the matter. Dillon Food Stores, Hutchinson, Kansas.

AOAC. 1970. "Official Methods of Analysis," 11th ed. Assoc. of Official Analytical Chemists, Washington, D.C.

Baldwin, R.E., Borcheet, D. and Cloninger, M. 1972. Palatability of ground beef home frozen and stored in selected wraps. Home Econ. Res. Journal 1: 119.

Bellis, D.R., Secrist, J.L. and Linskey, M.J. 1967. A comparison of solvent and thermal techniques for determining the fat content of ground beef. J. Food Sci. 32: 521.

Benson, P.L. and Ivey, M. 1961. Meat buying and storage practices of 61 Columbia, Missouri, homemakers. Research Bull. 768, Missouri Agric. Exp. Stn., Columbia, Mo.

Bligh, E.G. and Dyer, W.J. 1959. A rapid method of total lipid extraction and purification. Can. J. Biochem. Physiol. 37: 911.

Carpenter, Z.L. and King, G.T. 1969. Effects of composition upon ground beef palatability. Abstracts of Research Reports presented at the 15th European Meeting of Meat Research Workers, August 18-24, at Helsinki, Finland. p. 4.

Cohen, E.H. and Kimmelman, C.P. 1972. Proposed technique for the determination of both moisture and fat in the same sample of meat or meat product. J. Assoc. Offic. Anal. Chem. 55: 578.

Cole, J.W., Ramsey, C.B. and Odom, L.O. 1960. What effect does fat content have on palatability of broiled ground beef? Tenn. Farm and Home Sci. Progress Report 36: 5.

Davis, C.E., Ockerman, H.W. and Cahill, V.R. 1966. A rapid approximate analytical method for simultaneous determination of moisture and fat in meat and meat products. Food Technol. 20:1475.

Everson, C.W., Keyahian, T. and Doty, D.M. 1955. Rapid plant control methods for the determination of fat and moisture in meat and meat products. Am. Meat Institute Foundation Bull. 22: 30.

Federal Registrar. 1972. "Code of Federal Regulations," Title 9. sec. 319.15. Office of the Federal Registrar, Washington, D.C.

Folch, J., Ascoli, I., Lees, M., Meath, J.A. and LeBaron, F.N. 1951. Preparation of lipide extracts from brain tissue. J. Biol. Chem. 191: 833.

Folch, J., Lees, M. and Stanley, G.H.S. 1957. A simple method for the isolation and purification of total lipids from animal tissues. J. Biol. Chem. 226: 497.

Forss, D.A. 1969. Role of lipids in flavors. J. Agr. Food Chem. 17: 681.

Funk, K., Aldrich, P.J. and Irmiter, T.F. 1968a. Rate of temperature rise, physical and chemical properties of ground beef cylinders fabricated from selected muscles of the round. 2. Effect of bone. Food Technol. 22: 1183.

Funk, K., Aldrich, P.J. and Irmiter, T.F. 1968b. Rate of temperature rise, physical and chemical properties of ground beef cylinders fabricated from selected muscles of the round. 3. Effect of surface fat. Food Technol. 22: 1285.

Funk, K., Aldrich, P.J. and Irmiter, T.F. 1968c. Rate of temperature rise, physical and chemical properties of ground beef cylinders fabricated from selected muscles of the round. 4. Effect of surface connective tissue. Food Technol. 22: 1589.

Funk, K. and Boyle, M.A. 1972. Beef cooking rates and losses. J. of the Am. Dietetic Assoc. 61: 404.

Glover, R.S. 1964. Consumer preferences for ground beef and implications for cattle producers and beef distributors. Dissert. Abstr. 25: 154.

Hagan, S.N., Murphy, E.W. and Shelley, L.M. 1967. Extraction of lipids from raw beef lean by using various solvent systems. J. Assoc. Offic. Anal. Chem. 50: 250.

Hertz, K.O. and Chang, S.S. 1970. Meat flavor, In "Advances in Food Research," p. 2. Academic Press, Inc., New York.

Hornstein, I. and Crowe, P.F. 1960. Flavor studies on beef and pork. J. Agr. Food Chem. 8: 494.

Hornstein, I. and Crowe, P.F. 1961. Meat flavors from fat--not lean. Agr. Res. 9 (7): 14.

Hornstein, I. 1970. Chemistry of meat flavor. In "The Science of Meat and Meat Products," p. 348. W.H. Freeman and Co., San Francisco.

Huffman, D.L. and Powell, W.E. 1970. Fat content and soya level effect on tenderness of ground beef patties. Food Technol. 24: 1418.

Irmiter, T.F., Aldrich, P.J. and Funk, K. 1967. Rate of temperature rise, physical and chemical properties of ground beef cylinders fabricated from selected muscles of the round. 1. Effect of fat content. Food Technol. 21: 770.

Jensen, L.B. 1949. "Meat and Meat Foods," p. 157. The Ronald Press Co., New York.

Kaiser, N.L., Rogers, R.W. and Haggan, F. 1970. Ground meat performance study. Mississippi Farm Research 33 (2): 2.

Kelley, D.C., Guerrant, R.E. and Mackintosh, D.L. 1954. A study of methods of testing and sampling for the determination of fat content of ground meat. Food Technol. 8: 273.

Law, H.M., Beeson, M.S., Clark, A.B., Mullins, A.M. and Murra, G.E. 1965. Consumer acceptance studies. II. Ground beef of varying fat composition. Louisiana Agr. Exp. Stn., Bull. 597.

Lawrie, R.A. 1966. "Meat Science," p. 312. Pergamon Press, Ltd., Oxford, England.

Lough, A.K., Navia, J.M. and Harris, R.S. 1966. Improved procedure for extracting food fatty acids. J. Am. Oil Chem. Soc. 43: 627.

Matz, S.A. 1962. "Food Texture," p. 130. Avi. Publishing Co., Westport, Conn.

Mize, J.J. 1972. Factors affecting meat purchases and consumer acceptance of ground beef at three fat levels with and without soya-bits. Southern Cooperative Series Bull. 173.

Moreau, J.R. and Galhidi, J. 1971. A new rapid method for measuring the fat content in meat and meat products. J. Inst. Can. Technol. Aliment. 4 (4): 154.

Moreau, J.R. and Lavoie, M.T. 1971. An emulsion method for rapid determination of fat in raw meats. J. Food Sci. 36: 760.

Nielsen, M.M., Hall, F.T., Monsen, E.R. and Worthington, B. 1967. Eating quality, nutritive value, and cost of ground round and hamburger. J. Am. Dietetic Assoc. 50: 201.

Ostrander, J. and Dugan, L.R. Jr. 1961. A rapid, quantitative lipid extraction method. Bull. 50, Am. Meat Instit. Found. Chicago, Ill.

Paul, P.C. 1965. Current research on meat. J. Am. Dietetic Assoc. 46: 468.

Paul, P.C. 1972. Meat. In "Food Theory and Applications," p. 335. John Wiley and Sons, Inc., New York.

Price, J.F. 1971. Quality control and sanitation. In "The Science of Meat and Meat Products," p. 610. W.H. Freeman and Co., San Francisco.

Salwin, H., Bloch, I.K. and Mitchell, J.H. Jr. 1955. Rapid determination of fat in meat products. J. Agr. Food Chem. 3: 588.

Snedecor, G.W. 1956. "Statistical Methods," p. 122. Iowa State University Press, Ames, Iowa.

Thille, M., Williamson, L.J. and Morgan, A.F. 1932. The effect of fat on shrinkage and speed in the roasting of beef. J. of Home Econ. 24: 720.

USDA, 1968a. Household food consumption survey, Spring, 1965, Report No. 1, "Food Consumption of Households in the U.S.," U.S. Govt. Printing Office, Washington, D.C.

USDA, 1968b. "World Agricultural Production and Trade Statistical Report," U.S. Dept. Agr., Foreign Agr. Serv., Washington, D.C.

Wasserman, A.E. and Talley, F. 1968. Organoleptic identification of roasted beef, veal, lamb and pork as affected by fat. J. Food Sci. 33: 219.

Weir, C.E., Slover, A., Pohl, C. and Wilson, G.D. 1962. Effect of cooking procedures on the composition and organoleptic properties of pork chops. Food Technol. 16 (5): 133.

Weir, C.E. 1960. Palatability characteristics of meat. In "The Science of Meat and Meat Products," p. 212. W.H. Freeman and Co., San Francisco.

Whalen, F. 1966. A modified Babcock procedure for rapid determination of fat in meats using dimethyl sulfoxide. J. Assoc. Offic. Agr. Chem. 49: 1225.

Windham, E.S. 1957. Report on rapid methods for determination of fat in meat products. J. Assoc. Offic. Agr. Chem. 40: 765.

Wistreich, H.E., Thompson, J.E. and Karmas, E. 1960. Rapid method for moisture and fat determination in biological materials. Anal. Chem. 32: 1054.

Woods, B.L. and Jenkins, M.C. 1963. Motivations in consumer purchases of beef. Bull. 565. Louisiana St. Univ. Agr. Exp. Stn., Baton Rouge, La.

Woolsey, A.P. and Paul, P.C. 1969. External fat cover influence on raw and cooked beef. 1. Fat and moisture content. J. Food Sci. 34: 554.

ACKNOWLEDGMENTS

The author is sincerely grateful to Dr. Dorothy L. Harrison, her major professor and Professor of Foods and Nutrition, for assistance in planning the study and for encouragement and advice throughout the laboratory work and preparation of the manuscript.

Appreciation is expressed to Dr. Lucille M. Wakefield, Head of the Department of Foods and Nutrition, Dr. Jane R. Bowers, Associate Professor of Foods and Nutrition, and Dr. Willard S. Ruliffson, Professor of Biochemistry, for participating on the advisory committee and offering constructive suggestions for the manuscript.

Appreciation is extended to Dr. Arthur D. Dayton, Associate Professor of Statistics and Computer Science, for designing the experiment and helping with the analysis and interpretation of data.

The writer also wishes to thank Mrs. Lois Anderson and Miss Mary Bennett for laboratory assistance and the graduate students who served on the palatability panel.

Sincere appreciation is further expressed to Mr. Larry Kendall, husband of the author, for assistance in proofreading and for patience, understanding and moral support throughout the period of graduate study, and to Kristin Amy Kendall, daughter of the author, who after her arrival on September 11, 1972, provided refreshing moments of diversion.

APPENDIX

Form I

SCORE CARD FOR GROUND BEEF 1972-73 Hatch # 863

Panel member ______________ Code ______________ Date ______________

Sample no.	Desirability of flavor	Texture	Juiciness	Over-all Acceptability	Comments
1					
2					
3					
4					
5					

Descriptive terms for scoring:

Desirability of flavor[a]	Texture[b]	Juiciness	Over-all Acceptability[a]
5 Extremely desirable	5 Mealy	5 Extremely juicy	5 Extremely desirable
4 Desirable	4 Moderately mealy	4 Juicy	4 Desirable
3 Moderately desirable	3 Slightly mealy	3 Moderately juicy	3 Moderately desirable
2 Slightly undesirable	2 Slightly chewy	2 Slightly dry	2 Slightly undesirable
1 Undesirable	1 Chewy	1 Dry	1 Undesirable

[a] If scored below 3, please comment

[b] Texture - mealy - fine texture, friable
chewy - coarse texture, cohesive

Form II

Instructions to Judges for Sensory Evaluation of Ground Beef

Select one cube of meat to score all palatability characteristics for one sample.

Scoring for flavor and juiciness

Record a score for flavor and another for juiciness within a range of 5 to 1 that describes your impression of the sample. See the score card for descriptive terms for specific scores within the range of 5 to 1. Record the score describing your impression of flavor and juiciness at the beginning of the chewing process.

Scoring for texture

Record a score for texture within a range of 5 to 1 that describes your impression of the sample as you chew it. See the score card for descriptive terms for specific scores within the range of 5 to 1. A score of 5 will indicate a mealy product with a fine, friable texture, whereas a score of 1 will indicate a chewy product whose texture is coarse and cohesive.

Scoring for over-all acceptability

Record a score that describes your impression of the general desirability of the sample. This is not a total score, i.e., it is not a score obtained by adding the scores for the other factors. Score over-all acceptability with the range of 5 to 1, the same as for the other factors listed on the score card.

Comments

Comments about a sample and/or explanation of your reason for giving a particular score are helpful, especially if a sample is scored low.

Take your time to score each sample. To clean and rinse out the taste left in your mouth before tasting another sample, water and crackers are provided.

Table 8-Percentage ether extract, raw and cooked

Store	week	Product 1	Product 2	Product 3	Store	week	Product 1	Product 2	Product 3
		Ether extract, % raw					Ether extract, % cooked		
A	1	32.4	32.8	10.4	A	1	23.2	20.5	14.0
	2	38.7	26.7	11.1		2	18.3	19.9	11.5
	3	23.3	26.7	12.5		3	20.4	12.3	13.8
	4	28.1	20.0	7.8		4	19.1	17.5	17.7
	5	29.4	27.7	8.8		5	18.0	17.5	10.5
	6	33.1	27.0	6.0		6	21.5	20.3	8.6
	Av.	30.8	26.8	9.4		Av.	20.1	18.0	12.7
B	1	24.5	21.0	12.9	B	1	15.5	16.5	14.1
	2	32.7	29.6	11.7		2	17.8	18.4	11.2
	3	29.6	23.7	10.8		3	20.4	15.5	19.6
	4	28.9	21.4	9.3		4	19.3	17.0	9.2
	5	31.6	27.4	7.4		5	19.9	17.2	9.0
	6	27.5	23.4	16.0		6	17.5	20.1	14.1
	Av.	29.1	24.4	11.4		Av.	18.4	17.5	12.9
C	1	21.2	12.2	13.2	C	1	17.9	13.1	9.9
	2	25.9	8.1	8.9		2	20.3	8.6	12.0
	3	23.5	5.2	5.6		3	17.4	8.5	7.9
	4	18.7	10.0	9.9		4	16.7	12.7	10.5
	5	22.5	7.6	10.1		5	17.1	7.5	10.8
	6	20.8	9.8	11.7		6	21.0	17.0	12.8
	Av.	22.1	8.8	9.9		Av.	18.4	11.2	10.7

Table 9-Percentage cooking losses - total, volatile and drip

		Product			Product			Product		
S[a]	week	1	2	3	1	2	3	1	2	3
		Total, %			Volatile, %			Drip, %		
A	1	38.0	33.9	21.1	15.9	15.6	17.6	21.7	18.1	3.5
	2	26.7	29.1	19.6	15.9	17.6	18.1	10.6	11.3	1.5
	3	34.4	29.6	22.6	20.7	17.2	19.4	13.5	12.4	3.0
	4	32.6	28.5	21.8	17.0	16.7	16.9	15.4	11.1	4.4
	5	29.1	22.8	18.1	14.6	15.2	16.7	13.9	7.2	1.3
	6	32.0	27.8	19.4	14.6	14.8	17.0	16.7	12.2	1.9
	Av.	32.1	28.6	20.4	16.5	16.2	17.6	15.3	12.1	2.6
B	1	26.5	27.6	24.4	15.4	16.7	19.8	10.9	10.6	4.6
	2	36.1	34.1	23.1	16.3	16.1	19.4	19.8	17.8	3.7
	3	30.0	36.1	21.3	16.1	21.3	18.0	13.3	14.6	3.0
	4	29.6	27.0	17.8	15.2	19.4	15.6	14.3	7.0	1.7
	5	39.1	29.1	18.1	16.9	16.1	16.5	21.9	12.6	1.3
	6	27.0	23.9	20.4	14.4	15.6	16.7	11.5	7.6	3.1
	Av.	31.4	29.6	20.9	15.7	17.5	17.7	15.3	11.7	2.9
C	1	25.4	14.3	18.7	17.6	11.9	16.1	7.4	2.0	2.8
	2	27.4	18.5	21.7	18.5	17.0	18.9	8.9	1.5	2.4
	3	28.0	17.8	20.2	18.3	16.3	18.5	9.1	1.3	1.5
	4	27.6	18.9	18.5	15.9	16.3	16.3	10.7	2.2	1.9
	5	24.3	19.2	18.5	18.1	17.0	16.1	5.9	1.7	1.9
	6	23.7	20.0	21.3	15.4	16.3	18.5	7.6	3.1	2.2
	Av.	26.1	18.1	19.8	17.3	15.8	17.4	8.3	2.0	2.1

[a]Store

Table 10-Price per lb, cost per 100-g cooked serving

Store	week	Product 1	Product 2	Product 3	Store	week	Product 1	Product 2	Product 3
		Price per lb, cents					Cost per 100-g cooked serving, cents		
A	1	69.0	79.0	99.0	A	1	24.5	26.3	27.6
	2	69.0	79.0	99.0		2	20.7	24.5	27.1
	3	69.0	79.0	99.0		3	23.2	24.7	28.2
	4	69.0	79.0	99.0		4	22.6	24.3	27.9
	5	69.0	79.0	99.0		5	21.4	22.5	26.6
	6	75.0	85.0	105.0		6	24.3	25.9	28.7
	Av.	70.0	80.0	100.0		Av.	22.8	24.7	27.7
B	1	69.0	79.0	99.0	B	1	20.7	24.0	28.8
	2	69.0	79.0	99.0		2	23.8	26.4	28.4
	3	69.0	79.0	99.0		3	21.7	27.2	27.7
	4	69.0	79.0	99.0		4	21.6	23.8	26.5
	5	69.0	79.0	99.0		5	25.0	24.5	26.6
	6	73.0	85.0	105.0		6	22.0	24.6	29.1
	Av.	69.7	80.0	100.0		Av.	22.5	25.1	27.9
C	1	73.0	95.0	105.0	C	1	21.6	24.4	28.5
	2	73.0	95.0	105.0		2	22.2	25.7	29.5
	3	73.0	95.0	105.0		3	22.3	25.5	29.0
	4	73.0	95.0	105.0		4	22.2	25.8	28.4
	5	73.0	95.0	105.0		5	21.2	25.9	28.4
	6	79.0	99.0	109.0		6	22.8	27.3	30.5
	Av.	74.0	95.7	105.7		Av.	22.1	25.8	29.0

Table 11-Internal temperature, °C; total moisture, %; depth of penetration, mm

S[a]	week	Product 1	Product 2	Product 3	Product 1	Product 2	Product 3	Product 1	Product 2	Product 3
		Internal temperature, °C			Total moisture, %			Depth of penetration, mm		
A	1	75.0	71.0	65.0	53.6	55.3	60.7	11.0	15.2	11.4
	2	70.0	71.0	68.0	58.5	58.5	62.9	16.7	13.7	8.4
	3	75.0	72.0	70.0	53.1	62.9	61.2	9.2	13.0	12.9
	4	68.0	71.0	66.0	53.8	56.7	57.4	11.8	10.0	14.6
	5	72.0	67.0	64.0	58.8	58.3	63.4	10.2	12.1	14.8
	6	70.0	69.0	64.0	55.6	56.5	65.1	12.5	12.8	10.7
	Av.	71.7	70.2	66.2	55.6	58.0	61.8	11.9	12.8	12.1
B	1	66.0	71.0	68.0	60.0	60.0	61.4	14.8	14.3	11.4
	2	72.0	68.0	70.0	55.0	57.9	63.1	14.0	10.9	12.8
	3	65.0	78.0	67.0	57.2	58.4	54.8	10.4	10.6	12.7
	4	69.0	66.0	65.0	55.9	58.7	66.6	13.3	14.6	14.2
	5	76.0	68.0	65.0	55.3	58.3	66.0	14.5	14.3	14.2
	6	69.0	64.0	62.0	56.7	57.4	59.9	16.9	13.5	12.5
	Av.	69.5	69.2	66.2	56.7	58.5	62.0	14.0	13.1	13.0
C	1	67.0	66.0	67.0	59.1	61.0	65.0	15.6	14.3	12.6
	2	71.0	67.0	66.0	55.2	65.3	62.6	13.6	11.3	10.1
	3	71.0	65.0	69.0	59.1	66.0	65.9	13.2	13.6	9.6
	4	67.0	66.0	66.0	57.5	62.8	64.0	13.9	10.5	9.3
	5	67.0	64.0	62.0	54.2	66.8	65.0	13.6	15.3	11.2
	6	68.0	66.0	68.0	58.4	60.4	62.9	17.6	16.7	15.8
	Av.	68.5	65.7	66.3	57.3	63.7	64.2	14.6	13.6	11.4

[a]Store

Table 12-Press fluids: total, serum, fat, solids

		Product			Product			Product			Product		
S[a]	week	1	2	3	1	2	3	1	2	3	1	2	3
		Total, ml/25g			Serum, ml/25g			Fat, ml/25g			Solids, ml/25g		
A	1	8.0	8.0	6.8	3.8	4.1	3.8	2.5	2.4	0.4	1.8	1.5	2.6
	2	7.0	7.0	7.3	4.9	4.8	6.1	1.8	1.9	1.0	0.3	0.4	0.2
	3	7.3	7.5	7.5	4.4	5.6	5.7	2.7	1.8	1.6	0.2	0.2	0.2
	4	7.7	8.0	8.4	4.6	5.2	5.0	2.9	2.5	2.4	0.2	0.4	1.0
	5	6.9	7.4	8.0	4.4	5.4	6.9	2.3	1.9	0.9	0.2	0.1	0.2
	6	7.3	8.5	7.4	4.4	5.0	6.6	2.4	2.5	0.8	0.5	1.0	0.1
	Av.	7.4	7.7	7.6	4.4	5.0	5.7	2.4	2.2	1.2	0.5	0.6	0.7
B	1	7.6	8.7	7.0	4.9	5.8	4.4	0.8	0.0	0.5	1.8	3.4	2.0
	2	6.4	7.4	6.6	4.3	4.4	5.3	1.9	2.8	0.7	0.3	0.2	0.6
	3	7.3	7.1	6.7	4.5	4.4	3.8	2.2	2.5	2.2	0.6	0.2	0.7
	4	6.8	6.9	7.1	3.9	4.8	5.7	2.2	1.9	0.2	0.8	0.3	1.2
	5	6.7	6.8	6.5	4.4	4.4	4.8	2.1	2.0	0.5	0.2	0.4	1.2
	6	7.2	7.2	6.9	4.8	3.4	5.6	2.1	0.5	0.8	0.4	3.3	0.6
	Av.	7.0	7.4	6.8	4.5	4.5	4.9	1.9	1.6	0.8	0.7	1.3	1.1
C	1	8.0	7.4	8.0	5.3	4.8	6.8	1.6	0.8	1.0	1.0	2.0	0.2
	2	7.0	6.8	6.7	4.0	5.9	4.4	2.6	0.8	0.5	0.4	0.1	1.9
	3	7.3	6.5	6.3	5.0	5.5	5.4	2.3	0.9	0.8	0.0	0.1	0.2
	4	6.8	6.3	7.0	4.7	4.3	5.5	1.9	0.9	1.1	0.2	1.1	0.4
	5	6.0	7.3	6.6	3.8	6.4	5.0	2.0	0.7	0.4	0.3	0.2	1.3
	6	8.4	8.0	6.9	4.5	5.7	4.6	0.5	1.5	0.5	3.4	0.8	1.9
	Av.	7.3	7.1	6.9	4.6	5.4	5.3	1.8	0.9	0.7	0.9	0.7	1.0

[a] Store

Table 13-Scores for flavor,[b] texture,[c] juiciness[d] and over-all acceptability,[b] 1-5

S[a]	week	Product 1	Product 2	Product 3	Product 1	Product 2	Product 3	Product 1	Product 2	Product 3	Product 1	Product 2	Product 3
		Flavor[b]			Texture[c]			Juiciness[d]			Over-all acceptability[b]		
A	1	3.0	3.6	3.6	2.1	3.0	3.7	3.1	2.7	3.0	2.7	3.3	3.6
	2	3.1	3.2	1.7	4.0	2.3	3.5	3.7	3.2	1.8	3.4	3.0	1.7
	3	3.3	2.5	2.7	3.5	3.3	3.3	3.0	3.2	3.0	3.2	2.3	2.7
	4	3.0	3.2	3.5	2.2	3.2	4.0	2.7	3.7	3.8	3.0	3.5	4.0
	5	3.5	3.3	1.5	2.8	3.0	4.2	3.2	3.5	2.7	3.5	3.3	1.5
	6	3.0	3.0	2.8	2.8	2.5	2.3	3.8	3.7	2.8	3.0	3.2	3.0
	Av.	3.2	3.1	2.6	2.9	2.9	3.5	3.3	3.3	2.9	3.1	3.1	2.8
B	1	3.1	3.7	3.0	2.6	2.4	4.0	3.1	3.6	3.0	3.4	3.6	2.9
	2	3.4	2.9	3.8	2.6	3.0	3.2	3.1	3.6	3.0	3.3	3.0	3.3
	3	3.7	2.5	2.8	4.0	1.7	3.7	4.7	1.8	3.3	3.7	2.0	3.0
	4	3.6	3.7	3.0	3.9	3.3	3.1	4.0	3.3	3.1	3.4	3.8	2.9
	5	3.4	3.4	3.1	2.6	3.4	3.7	2.9	3.1	3.1	3.1	3.3	3.6
	6	4.0	3.2	3.2	2.3	4.0	3.3	3.8	4.2	2.7	3.8	3.3	3.0
	Av.	3.5	3.2	3.2	3.0	3.0	3.5	3.6	3.3	3.0	3.5	3.2	3.1
C	1	2.9	3.6	2.4	2.1	3.4	3.9	2.9	2.7	2.6	2.9	3.4	2.7
	2	3.5	3.6	3.5	3.7	2.9	3.5	3.3	2.3	3.2	3.3	3.1	3.2
	3	3.5	3.0	4.0	2.0	2.8	4.0	3.0	2.7	2.7	3.2	2.8	3.5
	4	3.3	2.9	2.7	2.9	4.0	3.3	4.0	3.4	3.2	3.1	3.0	3.2
	5	2.9	3.3	2.7	3.4	3.6	2.7	3.4	2.7	3.3	3.0	3.3	2.7
	6	3.2	3.2	3.0	3.8	3.7	3.8	4.0	4.0	3.5	3.5	3.2	3.0
	Av.	3.2	3.3	3.1	3.0	3.4	3.5	3.4	3.0	3.1	3.2	3.1	3.1

[a]Store

[b]Range, 5=extremely desirable; 1=undesirable

[c]Range, 5=mealy; 1=chewy

[d]Range, 5=extremely juicy; 1=dry

Table 14-Analysis of variance for effects of products, stores and weeks on objective and subjective measurements

Source of variation	d/f	Ether extract		Cooking losses			Cost/100-g serving
		Raw meat	Cooked meat	Total	Volatile	Drip	
		F-values					
Product (P)	2	119.4***	32.1***	43.2***	3.6*	78.0***	125.0***
Store (S)	2	38.2***	9.3**	21.8***	0.1	32.6***	1.6
Week (W)	5	2.0	1.2	1.2	4.2**	0.7	1.8
PS	4	12.7***	2.8	5.6**	2.3	7.2***	1.8
PW	10	0.7	1.1	0.4	1.2	0.5	0.3
SW	10	0.7	1.2	2.1	1.0	2.7*	1.9
Error	20						
Total	53						

Table 14-(continued)

Source of variation	d/f	Internal temp.	Total moisture	Press fluid			
				Total	Serum	Fat	Solids
		F-values					
Product (P)	2	6.8**	26.6***	1.9	4.8*	14.9***	0.4
Store (S)	2	3.2	8.5**	7.6**	1.7	7.0***	1.2
Week (W)	5	1.9	0.4	5.3**	0.1	2.0	5.4**
PS	4	1.2	1.6	1.2	0.8	0.8	0.4
PW	10	0.7	0.9	1.4	0.4	0.3	0.6
SW	10	0.6	1.3	1.7	1.2	1.2	1.0
Error	20						
Total	53						

Table 14-(concluded)

Source of variation	d/f	Penetration	Flavor	Texture	Juiciness	Over-all acceptability
			Sensory scores			
		F-values				
Product (P)	2	2.5	3.0	3.1	2.6	1.4
Store (S)	2	1.8	2.5	0.4	0.4	1.2
Week (W)	5	2.4	0.3	0.2	1.9	0.8
PS	4	1.6	0.5	0.3	0.6	0.3
PW	10	1.3	1.3	1.0	0.7	1.2
SW	10	1.4	1.2	0.5	0.3	0.5
Error	20					
Total	53					

$*P<0.05$; $**P<0.01$; $***P<0.001$

"QUALITY" ATTRIBUTES OF GROUND BEEF PURCHASED ON THE RETAIL MARKET

by

PATRICIA ANN KENDALL

B. S., Kansas State University, 1969

AN ABSTRACT OF A MASTER'S THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Foods and Nutrition

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1973

Ground beef, chopped beef or hamburger sold in interstate commerce or in Kansas may contain as much as 30% fat by weight. As this is a large allowance for lipid content, many retailers market ground beef at three or more fat and price levels, a practice that allows consumers a choice, but also leads to confusion at the meat counter.

To investigate the practice, packaged ground beef products with three different ratios of fat/lean were selected randomly from meat display cases of three local retail markets on six Mondays. The products were randomized for cooking and evaluation on Tuesdays and Wednesdays. Patties (180-g each) were cooked by modified broiling at 177°C for 35 min and evaluated for cooking losses, palatability and related "quality" factors and cost per 100-g serving.

As price of the ground beef products increased, percentage ether extract (lipid), in both raw and cooked meat decreased ($P<0.05$). Total and drip cooking losses decreased ($P<0.05$) with decreasing lipid in raw meat. Percentage yield of cooked meat equaled 85.4 minus 0.55 of percentage ether extract (lipid) in the raw meat. As percentage lipid decreased, the decrease in total cooking losses was not great enough to compensate for the increase in price per lb; therefore, the cost per 100-g serving of cooked meat increased ($P<0.05$) with decreasing lipid content.

Volatile losses were greater ($P<0.05$) and internal temperature lower ($P<0.05$) for the leanest product than for the other two products. Total press fluid and depth of penetration by a 150-g cone did not vary significantly among products, but as lipid content decreased, press fluid contained more ($P<0.05$) serum and less ($P<0.05$) fat. Differences among products in flavor, juiciness, texture and over-all acceptability, as judged by a 7-member laboratory taste panel, were not significant.

Under the conditions of this study, it was concluded that:

1. Ground beef that contains 10 to 20% lipid has less cooking loss than ground beef that contains 25 to 30% lipid.
2. In general, percentage ether extract (lipid) decreases with broiling when raw ground beef contains 20 to 30% lipid, and increases with broiling when the raw meat contains less than 12% lipid; therefore, the difference in lipid content between the above two classifications of ground beef products is not as great for broiled as for raw meat.
3. At prices less than $1.30 per lb for raw ground beef, cost per lb and per serving of cooked meat is less for lower-priced, higher-lipid products (decreasing in increments of $0.10 per lb and increasing in increments of 10% lipid), than for higher-priced, leaner products. For example, the cost of a cooked lb of ground beef is $0.04 less for raw ground beef priced at $0.90 per lb with a lipid content of 30%, than for raw ground beef priced at $1.00 per lb with a 20% lipid content.
4. The ratio of fat/lean had no significant effect on the palatability of the ground beef products.