FLAVOR, AROMA AND COLOR INFLUENCES ON CONSUMER ACCEPTANCE AND FLAVOR PROFILE ANALYSIS OF POLYVINYL CHLORIDE AND VACUUM PACKAGED GROUND BEEF

by

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ORGANIZATION OF THE THESIS

This thesis is presented in a series of chapters. Chapter I is a general introduction to the thesis. Chapter II includes a general review of literature pertaining to all topics discussed herein. The three chapters following the general review of literature are separate but related studies written as technical papers to be submitted for publication.

Chapter VI is an appendix which includes ballots, questionnaires, randomization procedures and a preliminary study. The preliminary study conforms to the style guide for research papers of the Journal of Consumer Research.

Chapter VII is a general abstract of the Master's thesis.

These sections conform to the style guide for research papers of the Journal of Food Science.

Chapter 1

GENERAL INTRODUCTION

Americans consume 145 lb/person of red meat per year on a retail weight basis. Forty percent of the beef is consumed in ground form (Brown, 1978). Ground beef is purchased and prepared by 78% of U.S. households at least once every two weeks (National Live Stock and Meat Board, 1985), is a relatively inexpensive beef product, can be prepared in numerous ways, and its flavor is liked by many market segments (Mize, 1972). An estimated 4% of the U.S. family food budget is spent on ground beef (Sink, 1980). Current retail packaging systems produce a ground beef retail display life of only 2-5 days and a high price discounting frequency because of discoloration. These problems result from prolonged exposure to oxygen and from microbial contamination and growth during processing and display.

Merchandising ground beef in its purple, reduced myoglobin chemical state (vacuum packaging), rather than the bright red oxymyoglobin state (oxygen permeable packaging), offers the following potentials: improving product acceptability and consumer perception of freshness and quality; extending display life; reducing product loss, and lowering transportation and delivery costs. However, consumer reaction to vacuum packaged products and the necessity of educating the consumer before marketing them, have not been thoroughly researched. Furthermore, color, flavor, and aroma differences between vacuum packaged and oxygen permeable packaged of ground beef and

their influence on consumer acceptance have not been determined.

The objective of Chapter III research was to determine consumer reaction to vacuum packaged ground beef. Consumer responses were evaluated to determine the influence of color on purchase intent, and if purchase intent was increased by a consumer information program regarding vacuum packaging. Chapter IV experimentation studied both the ability of untrained judges to differentiate between vacuum and polyvinyl chloride packaged ground beef and subsequently their product preferences. Chapter V work qualified and quantified the similarities and differences in aroma and flavor characteristics of the two products using flavor profile analysis.

Chapter II

REVIEW OF LITERATURE

Current retail packaging systems (i.e., oxygen permeable films) give ground beef a retail display life of 2-5 days and a high frequency of price discounting because of discoloration or loss due to spoilage (Hunt, 1984). These problems result from exposure to oxygen and microbial contamination and growth during processing and display. Merchandising ground beef in vacuum packaging rather than the predominant polyvinyl chloride (PVC) packaging materials may improve product acceptability, extend display life, reduce product loss, and lower distribution costs.

Vacuum packaging of wholesale cuts has become increasingly popular during the past decade. In 1973 it was estimated that 43% of the beef subprimals shipped to retail outlets were in vacuum packages. By 1982, this number was expected to increase to 90% (Shaw, 1973). This success indicates the potential advantage of the vacuum packaging of retail cuts (Taylor, 1982).

Films used for vacuum packaging should be strong, puncture resistant, sealable, low in moisture-vapor transmission rates and gas permeability rates (10-150ml $O_2/m^2/24$ hr at 700mm Hg and 25°C) (Johnson, 1974). Vacuum packaging seals meat in plastic film which is relatively impermeable to oxygen. The residual oxygen in the package drops to .5% within 2 or 3 days (Taylor,

1982). Baltzer (1969) claimed this drop in oxygen was due to the mitochondrial conversion of oxygen to carbon dioxide through respiration. Gardner et al. (1967), Johnson (1974), and Ingram (1962) believed bacteria also convert oxygen to carbon dioxide through respiration. These processes create carbon dioxide concentrations of over 20% and low oxygen concentrations which inhibit pseudomonas growth (Ingram, 1962; Ordal, 1962; Taylor, 1972; Grau, 1978) leaving lactobacillus as the predominant microflora. Since pseudomonads are normally responsible for spoilage, vacuum packaging extends the storage life of beef (Taylor, 1982).

COLOR

The heme pigment myoglobin is primarily responsible for the color of fresh meat (Schweigert, 1956). Myoglobin is a water- and dilute salt-soluble sarcoplasmic protein (Solberg, 1970). Its concentration in muscle is dependent on muscle activity, blood supply to the muscle tissue, oxygen availability and animal age (Clydesdale and Francis, 1971). Myoglobin can exist in many different pigment forms, as shown in Figure 1 (Lawrie, 1974).

The predominant pigment form is dependent on many factors such as: preslaughter stress, breed differences, maturity, marbling (Solberg, 1968), display lighting (Goll, 1984), meat pH (Cutaia and Ordal, 1964; Elliott, 1967), storage temperature (Rickert et al., 1957a, b; Fellers et al., 1963; Sandberg, 1970), microbial flora (Kraft and Ayres, 1954; Cutaia and Ordal, 1964), ionic strength, protein concentration, hemoglobin concentration, salt concentration

Figure 1 - Pigments found in fresh, cooked and cured meat (Lawrie, 1974)

Pigment	Pigment Formation	State	Color
Myoglobin (Mb)	Reduction of MMb,deoxygenation of MbO	Fe^{++}	Purplish red
Oxymyoglobin (MbO)	Oxygenation of Mb	Fe^{++}	Bright red
Metmyoglobin (MMb)	Oxidation of Mb or MbO	Fe^{+++}	Brown
Nitric oxide myoglobin	Combination of Mb with nitric oxide	Fe^{++}	Bright red (pink)
Nitric oxide metmyoglobin	Combination of MMb with nitric oxide	Fe^{+++}	Crimson
Metmyoglobin nitrite	Combination of MMb with excess nitrite	Fe^{+++}	Reddish-brown
Globin myohaemochromogen	Effect of heat, denaturing agents on Mb, MbO, haemichromogen;	Fe^{++}	Dull red
Globin myohaemichromogen	Effect of heat, denaturing agents on Mb, MbO, MMb haemochromogen	Fe^{+++}	Brown (sometimes grey)
Nitric oxide myohaemochromogen	Effect of heat, denaturing agents on nitric oxide Mb	Fe^{++}	Bright red (pink)
Sulphmyoglobin	Effect of H_2S and oxygen on Mb	Fe^{++}	Green
Oxysulphmyoglobin	Oxygenation of sulphmyoglobin	Fe^{+++}	Red
Metsulphmyoglobin	Oxidation of sulphmyoglobin	Fe^{++}	Red
Choleglobin	Effect of hydrogen peroxide on Mb or MbO; effect of ascorbic acid or other reducing agents on MbO	Fe^{++} or Fe^{+++}	Green
Nitrihaemin	Effect of large excess of nitrite and heat on nitric oxide Mb	Fe^{++}	Green
Verdohaem	Effect of excess denaturing agents	Fe^{++}	Green
Bile pigments	Effect of denaturing agents in large excess	Fe absent	Yellow or colorless

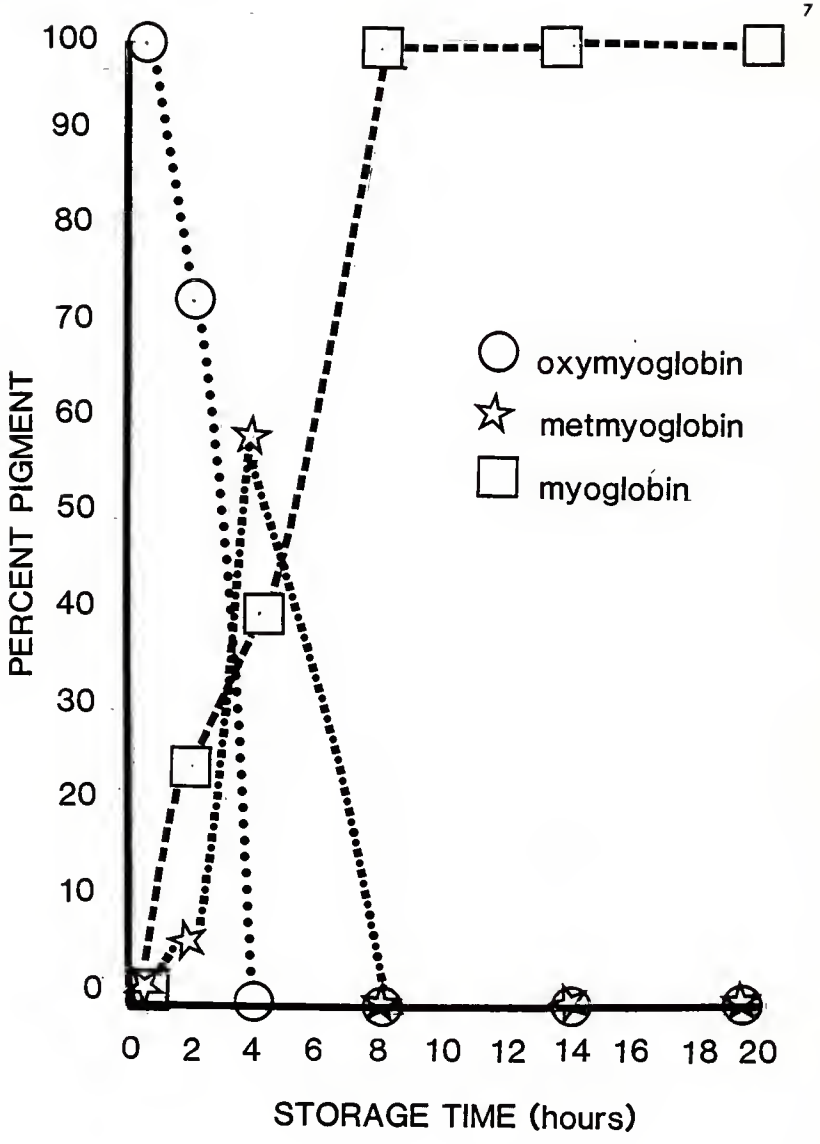
(Livingston and Brown, 1981), and package permeability to oxygen (Landrock and Wallace, 1955; Solberg, 1968; Pierson et al., 1970; Seideman et al., 1976b; Griffin et al., 1982).

Current PVC packaging enhances formation of the red oxymyoglobin pigment (MbO); vacuum packaging results in the purple, reduced myoglobin pigment (Mb) (Pierson et al., 1970). These authors documented the pigment changes occurring in vacuum packaged round steaks. After standardization, reflectance spectra were recorded from 400 to 700nm on a Bausch and Lomb spectrophotometer. Immediately after vacuum packaging they found a rapid decrease in the amount of MbO. The percentage of metmyoglobin (MMb) first increased, then decreased. The Mb percentage increased to 100% within eight hr. These results are shown in Figure 2 (Pierson et al., 1970). These authors suggested that initial MMb formation was due to autoxidation of ferrous pigments at low oxygen concentrations. When the oxidation-reduction potential becomes low enough, the MMb is reduced by transport of electrons from NADH to MMb, thus forming purple Mb (Saleh and Watts, 1968).

According to Watts et al. (1966), most of the oxygen in the package must be consumed before MMb reduction will occur. Until the residual oxygen level is sufficiently reduced to 1% or less, MMb is formed (Rikert et al., 1957a; Taylor, 1972).

Pirko and Ayres (1957) found MMb formation is usually complete 2-5 hr after packaging. However, Pierson et al. (1970) and Cutaia and Ordal (1964) found the rate of MMb formation was dependent on storage temperature. At higher temperatures, the amount of MMb formed is less, and its conversion to Mb is more rapid. Cutaia and Ordal (1964) also attributed the lower amount of

Figure 2 Initial pigment changes in anaerobically packaged beef stored at 3.3°C (Pierson et al., 1970).


100
90
80
70
60
50
40
30
20
10
0
PERCENT PIGMENT
oxymyoglobin
metmyoglobin
myoglobin
0
2
4
6
8
10
12
14
16
18
20
STORAGE TIME (hours)

MMb formation to the interaction of two systems. Because of the low oxygen concentrations, rapid autoxidation of MbO to MMb occurs (Snyder and Ayres, 1961). Secondly, grinding of meat allows for more rapid metabolic reactions than would be found in a solid cut. Since enzymatic activity increases with increasing temperature the reducing potential generated converts the MMb to Mb more rapidly at higher temperatures. The idea of this dual system interaction is supported by the work of Brown and Dolev (1963).

Another factor influencing the rate of Mb formation is the length of aerobic exposure before anaerobic packaging. Pierson et al. (1970) reported that the amount of MMb formed and the time required to convert it to Mb increased with increasing aerobic storage time. After 48 hr of aerobic storage, over 20 hr of vacuum-packaged storage were required to completely convert the pigment to reduced myoglobin.

After the initial conversion to Mb, the purple colored pigment persisted throughout anaerobic display (Pierson et al., 1970; Griffin et al., 1982). When packages are opened, Mb will rapidly "bloom" to the bright red MbO pigment (Jaye et al., 1962; Cutaia and Ordal, 1964; Pierson et al., 1970). However, if the package is opened when MMb dominates, the brown pigment persists (Cutaia and Ordal, 1964; Breidenstein, 1982).

Beef packaged in oxygen permeable packaging displays the red MbO pigment initially, but the surface rapidly oxidizes to MMb within 5 da at 3.3°C (Pierson et al., 1970). According to Jaye et al., (1962) this conversion begins after 2 da of storage.

Griffin et al. (1982) used a six member trained panel to evaluate the MbO color (15=bright cherry red, 1=extremely dark brown), Mb color (15=bright

purple-red, 1=extremely dark brown), and overall appearance (15=extremely desirable, 1=extremely undesirable) of vacuum packaged and PVC packaged beef loin steaks. From their results they inferred that when stored at 2°C, PVC samples were acceptable for 5 da and vacuum packaged counterparts were acceptable throughout the 30 da storage period.

CONSUMER PREFERENCE STUDIES

The fate of a food product has always rested on consumer acceptance, but formal consumer preference studies are a comparatively recent development, being especially emphasized in the 1970's. Consumer studies are popular for they present a useful approach to estimating product marketability (Morse, 1951).

One way of classifying consumer studies is on the basis of consumer participation in providing the information (Morse, 1951). One method is to interview consumers as to their perceptions of the product. This widely used method requires complete consumer participation. Testing usually takes place in store booths, lobbies, fairs, transportation centers and food markets (Simone and Pangborn, 1957; Coleman, 1964). According to the American Society of Testing and Materials (1979), the basic rationale of central location testing is that it allows information to be collected under reasonably controlled conditions; suitable equipment and testing space can be made available; personnel required to complete the test are relatively few; and the psychological environment can be controlled (instructions to panelists, method of examining samples, and ways

of responding to questionnaires).

Color: The appearance factor that probably determines most whether or not a meat package will be purchased is color (Marsh, 1960; El-Baldawi et al., 1964; Lund et al., 1968; Rust and Topel, 1969; Skinner, 1969; Hoke and Davis, 1970; Solberg and Franke, 1971; Ramsbottom, 1971; Riordan, 1973; Hood and Riordan, 1973; Lawrie, 1974; MacDougall and Taylor, 1975; Gerrard, 1977; Kropf, 1980). Not only do consumers judge product color (Judd and Wyszecki, 1963), but Birren (1963) found that certain birds and animals react the same way as humans do to color. Bright, "warm" colors of some foods affect man's digestive system, stimulating the autonomic nervous system, whereas soft, "cool" colors act the opposite. Apparently, color is a universal way of judging food product acceptability. This judging of a food products quality on the basis of its color probably occurs because our first impression of a product usually is visual (MacKinney and Little, 1962).

A product's color has a real and a psychological effect on the consumer (Hiner, 1954). Pangborn (1967) noted, "to a large extent, man recognizes, discriminates and selects nutrients with the eye. Through conditioning and association he expects an item of a certain shape and color to have a specific odor, taste, and texture." Perception is influenced by what is familiar, what one is looking for, memory, and experience (Kostyla and Clydesdale, 1978).

Color has a great influence on perceived product quality. Food product studies support this (Moir, 1936; Brice, 1953; MacKinney, 1953; Schutz, 1953; Kanig, 1955; Hall, 1958; Clydesdale, 1975; Dunker, 1980; Livingston and Brown, 1981). For example, consumers associate lighter colored beer with a lighter

taste and darker colored beer with a more bitter liquor taste. A general association can be made between beer color and consumer preference (Anonymous, 1982). Another example of this phenomenon is butter. Butter is tinted for color control. If it is too white it may resemble lard; if too yellow it may appear rancid to the consumer (Birren, 1982).

Despite these psychological effects, the consumer has learned to accept some food color differences. Since consumers have learned to accept the color difference resulting from the processing of frozen and canned peas (Ernst, 1980), perhaps they can learn to accept purple-colored ground beef.

Meat traders accept the idea of vacuum packaging beef retail cuts because they understand that the purple color associated with vacuum packaged beef is not an indicator of poor quality (Taylor, 1982). Consumers, used to seeing bright red meat, associate the red color with good quality (Tuma et al., 1973; Smith 1981; Taylor, 1982; Reynolds, 1983). Consumers immediately assess the color of a food product, using the information to arrive at a buy/no buy decision (MacKinney et al., 1960). According to Taylor (1982), there is little correlation between meat color and eating quality. This idea has dominated fresh meat marketing for a long time and has been a major hindrance to the introduction of alternative packaging forms, some of which have distinct advantages over the traditional packaging approaches.

Sebranek (1981) and Clydesdale and Francis (1976) stated that a foods' color is its most important sensory characteristic. The importance of meat color was demonstrated by Naumann et al. (1957), who found that consumers consider two different preferences in their meat purchasing. One is a minimum visual appearance if the meat cut is to be bought, while the other is palatability,

which is determined by the overall quality of the meat. Certainly, consumers have few if any means of estimating the flavor, juiciness and tenderness of a cut of meat while it is in the showcase, so they must base their selection on visual appearance. Color, of course, is much of what the consumer bases his choice on (Kropf, 1980).

Parents teach children to pick the bright red product when selecting beef at the grocery store (Smith, 1981). The typical consumer is proud of his ability to choose the packages having what he considers to be the most desirable color (Ernst, 1980). This discrimination is unfounded, yet consumers are still suspicious of any color abnormality in meat (Romans and Ziegler, 1977). According to Kemp (1980), color affects salability and appearance, even though it affects eating quality very little.

Studies have shown physical appearance of retail cuts to be the most important characteristic when selecting beef (Danner, 1959; Dunsing, 1959a,b). In a study of meat purchasing and preferences (Koudele et al., 1983), meat color was the most important factor to homemakers when selecting beef at retail outlets. Other selection factors evaluated, in order of importance were: amount of fat, price, grade or quality, amount of bone, marbling, package appearance, number of servings from each package, and label with preparation suggestions. Stevens (1956) and Mize (1972) concurred that color is very important to the consumer when purchasing beef. This is not to say that other factors are not important. Woods and Jenkins (1963) found price; amount, color and texture of lean; and USDA grade almost equally important. Koudele (1983) found color, amount of fat, and price all to be similar in importance. ASPC (1964), Rhodes et al., (1955) and Seltzer (1955) found that consumers select cuts primarily for

leanness. Next in importance were freshness and appearance, with these being based on brightness of color.

Demographics: Demographic factors have a large influence on consumer behavior. Woods and Jenkins (1963) found educational level was one important influence in consumers' beef purchases. Females with elementary or graduate school educations considered cost to be somewhat more important than other factors. High school and college graduates felt general product appearance was more important. Those employeed in unskilled positions were most concerned with general appearance of the cut. Cost was most important to those women who did not work outside the home.

Lund (1968) found low income households more responsive to price changes, advertising, and in-store promotion of meat (Webster County, Iowa), than higher income households or aged, extremely low income persons.

Consumer Education: Although much research has been conducted in the area of consumer acceptance of beef, few studies have focused on the acceptability of vacuum packaged beef. Small scale testing has been done in Minnesota (Ernst, 1980; O'Neill, 1981). Consumers did notice a color difference between polyvinyl chloride packaging (PVC) and vacuum packaging (VP), but did not react adversely. However, PVC and VP beef cuts were not displayed side by side. Results of a study conducted in Sweden where particular attention was paid to consumer education were favorable (Taylor, 1982).

Consumer education will determine vacuum packaged retail cut success (Ernst, 1980; Kropf, 1980; Smith, 1981; Taylor, 1982). Smith (1981) and others

believe vacuum packaging of retail cuts has great potential. The question is, can the consumer adapt to buying purple-colored beef? According to Taylor (1982) and Ernst (1980) a large consumer education program is the only tactic to overcome this problem.

Erdman, the pioneer in vacuum packaging of retail beef cuts, agrees. He says, "Consumer acceptance, however is another matter. You need constant education to get customers to try the beef. Customers come. Customers go. And I'm not sure at all that our initial efforts were on target. There was too much emphasis on the packaging and its clarity. The color of the meat was virtually ignored. Last January we 're-introduced' the package as Fresh-Seal rather than Clear-Cut and we're facing the color problem up front. The Fresh-Seal copy says meat is fresher because the package seals out air. And air is what causes beef to lose its freshness. So it's a fact that our vacuum-sealed chucks, etc., will be fresher than the same beef cut conventionally packaged at the same time. You'll see the difference in our naturally fresher, deeper red color." (O'Neill, 1981).

LIGHTING

Fluorescent lights have a majority of short (cool) wavelengths. Incandescent lights have a majority of long (warm) wavelengths (Evans, 1948). At equal foot candle intensities, deluxe fluorescent lights radiate about 20% as much heat as incandescent lamps according to lighting engineers (Kropf, 1980). Some fluorescent lights give off bluish tints, incandescent lights emit a greater

proportion of reddish tints. Birren (1963) stated that supermarkets should utilize neutral white or slightly warm (reddish) lights rather than cool (bluish) lights to increase impulse buying. Satterlee and Hansmeyer (1974) stated that meats lighted by incandescent lights rather than fluorescent lights require a longer time for oxidation of surface myoglobin. The shorter wavelengths of fluroscent lights cause more rapid discoloration to the metmyoglobin pigment (Archer and Bandfield, 1950; Zachariah and Satterlee, 1973). However, fluorescent lights are more efficient than incandescent lights (Parrott and Welsch, 1983) and they offer a slight bactericidal effect due to ultraviolet energy (Anonymous, 1978).

Light intensity varies greatly from store to store. Archer and Bandfield, (1950) found intensities varied from 35 to 100 foot candles at meat counters. In a Manhattan, Kansas survey (Kropf, 1971), intensities varied from 30 to more than 300 foot candles. The Illuminating Engineering Society (Anonymous, 1959) recommended 200 foot candles for display cases. Hansen and Sereika (1969) indicated that above 200 foot candles, rapid deterioration of meat color occurred.

Light accelerates both oxidation of fat (rancidity) and oxidation of the pigments (discoloration) (Watts, 1954). The temperature increase on the meats' surface creates more optimal conditions for microbial growth (Lechowich, 1970) and subsequent discoloration. Photosynthesized oxidation of unsaturated fats contributes to rancidity (Chan, 1977). Many agree that light has an adverse effect on meat color (Marriott et al., 1967; Solberg, 1968; Kennick et al., 1971). Ramsbottom et al. (1951) and Watts (1954) agreed that fresh meats are not discolored by display case lighting in a 3 da period. Kropf (1980) stated that although light did affect the pigment state, the eye may not be able to detect

these changes during early display periods.

MICROBIOLOGY

The microbial flora of meats vacuum packaged in low O_2 permeable film differs from that packaged in oxygen permeable film. The display life of beef is greatly increased by vacuum packaging as compared to PVC packaging (Gross, 1959; Ingram, 1962; Jaye et al., 1962; Ordal, 1962; Shank and Lundquist, 1963; Baran et al., 1970; Pierson et al., 1970; Joseph, 1971; Johnson, 1974; D'Alessandria and Pagliaro, 1975; Sutherland et al., 1975; Seideman et al., 1976a, b, c; Dainty et al., 1979; Newton and Rigg, 1979). This is due to the lower incidence of spoilage organisms in the vacuum packaged products (Baran et al., 1970; Pierson et al., 1970; Minks and Stringer, 1972; Hodges et al., 1974; Gill and Newton, 1978; Newton and Rigg, 1979), resulting from an increased lag phase of growth (Halleck et al., 1958; Baltzer, 1969; Pierson et al., 1970). At the low partial pressure of O_2 in vacuum packaged beef, the putrefactive aerobic bacteria cannot survive and anaerobes flourish. Figures 3, 4, and 5 illustrate the effect of storage time on the changes in microflora of aerobically and anaerobically packaged ground beef (Jaye et al., 1962; Ordal et al., 1962).

Aerobic Packaging: With PVC packaging, non-pigmented, aerobic, gram negative rods of pseudomonds predominate (Kirsh, 1952; Ayres, 1960; Pierson et al., 1970; Brown and Hoffman, 1972; Vanderzant et al., 1982). According to Kirsh (1952) and Rogers and McClesky (1957), Achromobacter also constitute a significant portion of the flora. Spoilage usually occurs before the pseudomonad

Figure 3 The effect of storage time on change in total bacterial counts of aerobically and anaerobically packaged ground beef (Jaye et al., 1962).

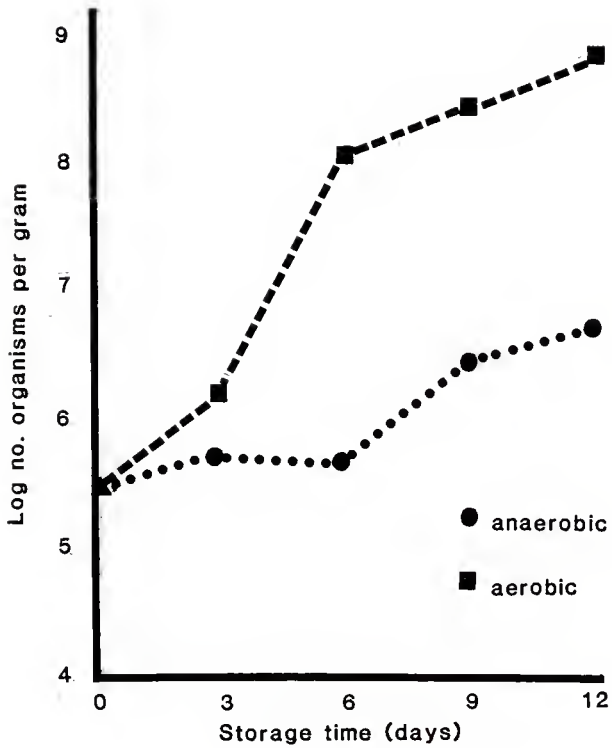

9
8
7
6
5
4
Log no. organisms per gram
0
3
6
9
12
Storage time (days)
anaerobic
aerobic

Figure 4 The effect of storage time on change in fluorescent pseudomonad bacterial counts of aerobically and anaerobically packaged ground beef (Jaye et al., 1962).

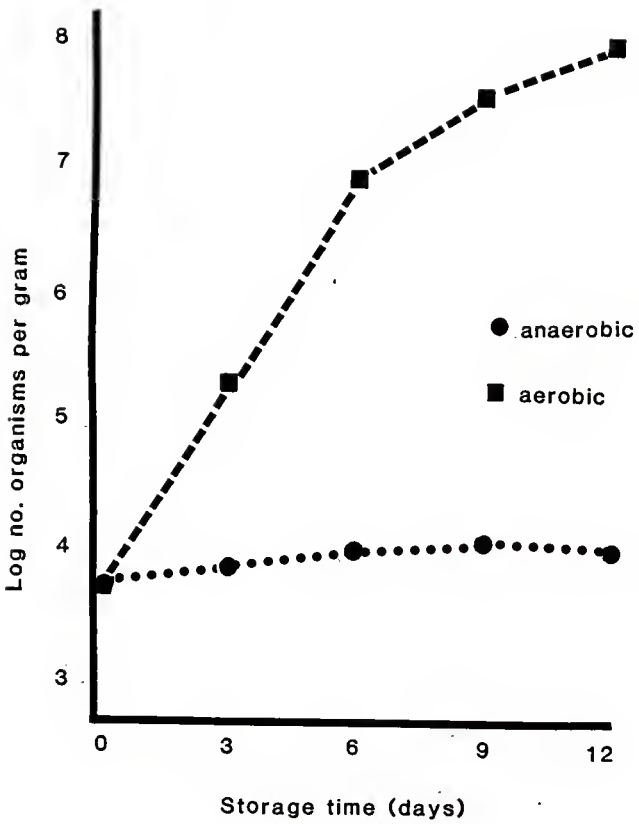
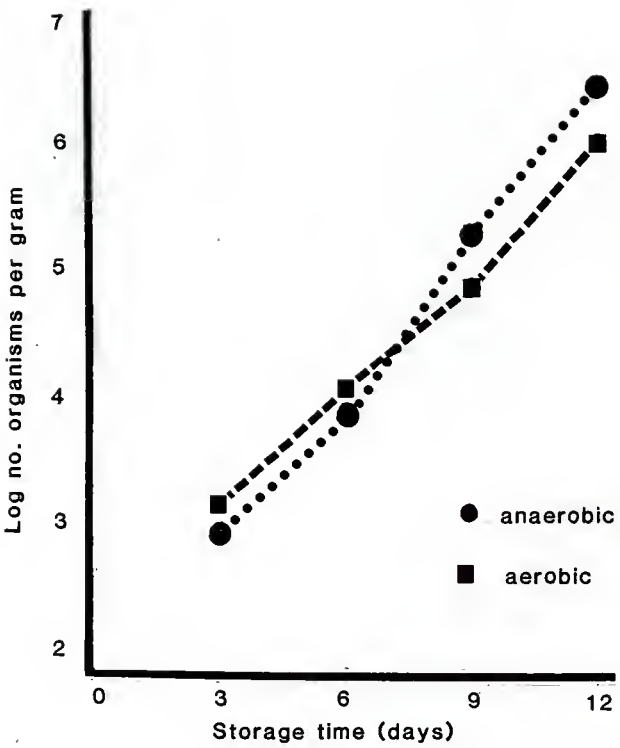

8
7
6
5
4
3
Log no. organisms per gram
anaerobic
aerobic
0
3
6
9
12
Storage time (days)

Figure 5 The effect of storage time on change in lactic acid bacterial counts of aerobically and anaerobically packaged ground beef (Jaye et al., 1962).


7
6
5
4
3
2
Log no. organisms per gram
0
3
6
9
12
Storage time (days)
anaerobic
aerobic

populations reach their maximum. Pseudomonads, which produce proteolytic enzymes, are psychro-tolerant, growing at refrigerator temperatures (4.4°C). They are responsible for the majority of the putrefactive surface spoilage of meats (Pierson et al., 1970; Brown and Hoffman, 1972).

Anaerobic Packaging: The degree of vacuum, partial pressure of O_2, residual air trapped in the package, an undetectable loss of vacuum, and presence of facultative aerobes or anaerobes will affect the amount of aerobic growth in vacuum packaged beef (Hodges et al., 1974). The total flora is affected by the composition of the initial bacterial flora, length of storage, storage temperature, film gas permeability, and concentration of CO_2 (Brown and Hoffman, 1972; Newton and Rigg, 1979). Of these, the principal factors affecting microbial growth on vacuum packaged meats are CO_2 concentration and storage temperature (Brown and Hoffman, 1972).

Although small quantities of Pseudomonas are present in vacuum packaged beef, Lactobacillus predominate (Ingram, 1962; Jaye et al., 1963; Ordal, 1962; Baran et al., 1970; Pierson et al., 1970; Seideman et al., 1976a; Sutherland et al., 1975; Dainty et al., 1979; Vanderzant et al., 1982). Anaerobic growth is enhanced by CO_2 production which in turn inhibits aerobic growth (Baltzer, 1969; Hodges et al., 1974). The increase in CO_2 concentration stimulates the growth of Lactobacilli or other metabolically related gram positive bacteria. Lactobacilli are facultative anaerobes which produce lactic acid. They obtain their energy for growth through the glycolytic pathways of fermentation (Brown and Hoffman, 1972). Lactobacillus is affected by temperature. Between 0-1°C, growth is greatly suppressed. At 3°C and above growth becomes rapid (Jaye et

al., 1962). These lactic acid bacteria contribute to the sour off flavors (Pierson et al., 1970), acid flavors (Patterson and Gibbs, 1977), sour and cheesy odors (Savell et al., 1981), gas production (Hanna et al., 1979), lowered surface pH (Hanna et al., 1980), and off aromas (Egan and Shay, 1982).

Vanderzant et al. (1982) have identified six species of Lactobacillus (both homo and hetero fermentative) in vacuum packaged beef loin steaks: Lactobacillus cellobiosus, Lactobacilllus viridescens, Lactobacillus coryneformis, Lactobacillus curvatus, Lactobacillus plantarum, and Lactobacillus xylosus.

Hanna et al. (1983) displayed vacuum packaged round steaks for 5-30 da at 2 or 7°C and found that Lactobacillus made up more than 50% of the microflora. Microorganisms isolated by other researchers were: Leconostoc spp., Brochothrix thermosphacta, Aeromonas hydrophila, Pseudomonas spp., Streptococcus spp., Moraxella-Acinetobacter spp., Serratia liquefaciens, Hafnia alvei, Alteromonas putrefaciens, Flavobacterium spp., and Proteus morganii (Vanderzant et al., 1982). Other reports cite Enterobacteriaceae (Enterobacter, Erwinia, Hafnia, Serratia, and Yersinia) (Bebbe et al., 1976; Hanna et al., 1976; Seideman et al., 1976a, b; Patterson and Gibbs, 1977; Hanna et al., 1979; Seelye and Yearbury, 1979) and Clostridium perfringens (Baran et al., 1970).

Comparison of Aerobic and Anaerobic Packaging: Several studies compared the microflora of vacuum packaged to PVC packaged beef. Baran et al. (1970) found aerobic growth in vacuum packaged products to be stationary after 6 da. Anaerobes increased up to 3 da, decreased to 20 da, and increased thereafter. PVC packaged products increased in aerobic counts to 21 da and decreased thereafter. Growth of anaerobes occured earlier in vacuum packaged

products, aerobes earlier in oxygen permeable packages.

Berry et al. (1971) compared vacuum packaged and PVC wholesale cuts stored for 11 da at 2°C. Nine wholesale cuts from each of left and right sides of 18 carcasses were used. Total plate counts were 1 to 2 log cycles higher for PVC than for the vacuum packaged cuts.

Brown and Hoffman (1972) compared choice beef loin steaks wrapped one day postmortem in Cry-O-Vac® saran bags (150-175ccO_2/m^2/24hr) to those wrapped in Primewrap PVC stretch film (15,000-20,000ccO_2/m^2/24hr). Microbial analyses were conducted at 4, 6, 8, 11, and 13 da postmortem. The bacterial load was similar for both packages through 6 da of storage at 0°C. After 6 da, counts in PVC continued to rise, those in saran remained the same. The bacteria found in the aerobic packages were mainly putrefactive Pseudomonas, those on the saran were mostly Lactobacillus, with some Pseudomonas and Bacilli.

Jaye et al. (1962) focused on bacteriological and organoleptic properties of vacuum packaged ground beef. Fresh rounds, beef trim and prepared ground beef with fat contents of approximately 20% were ground and packaged in either saran (oxygen impermeable) or MSAD80 cellophane (oxygen permeable). Samples were stored at either -1.1°C or 3.3°C until evaluated. The top center of the MSAD80 packaged meat, and the center portion and exterior portion just below the packaging film of the saran product were used for microbiological analysis. Type of packaging and storage temperature both affected microbiological growth. Fluorescent pseudomonads predominated in oxygen permeable packages; lactic acid bacteria in vacuum packages (over 50% of flora after 6-12 da of storage). The cellophane wrapped samples became putrid after 6 da of storage. After 8 da the saran wrapped samples had a slightly sour taste

due to the lactic acid bacteria. In a similar study, Pierson et al. (1970) found that at 15 da storage lactobacilli made up 90% of the microbial population in vacuum packaged samples.

Vanderzant et al. (1982) compared vacuum packaged beef strip loins to PVC packaged samples. Storage time before fabrication (0, 12, 24 da), display temperature (2°C, 7°C), and film permeability (PVC, medium and high oxygen barrier films) were compared. Pseudomonas spp. predominated on steaks displayed in PVC film. Vacuum packaged steaks displayed a predominance of Lactobacillus. Vacuum packaged steaks from 0 da loins displayed both homo- and heterofermentative strains, vacuum packaged steaks from 12 and 24 da loins displayed mostly heterofermentative strains. Differences ($P>.05$) were not found for display temperature.

Vacuum packaged meats are characterized by slow increases in total counts, souring rather than putrefaction or slime formation, and low final counts (Baltzer, 1969). The surface color of vacuum packaged fresh beef deteriorates very slowly as compared with PVC packages (Hanna et al., 1983). According to Brown and Hoffman (1972), "it is not uncommon to double or triple the shelf life of fresh beef with good sanitation and vacuum packaging".

PALATABILITY

Little research has focused on the flavor comparison and characterization of PVC and vacuum packaged beef. Onset of off flavors in aerobically and anaerobically packaged beef has been attributed to microbial growth (Jaye et

al., 1962; Pierson et al., 1970). However, reports of storage time before off flavor development differ. Jaye et al. (1962) reported souring of vacuum packaged ground beef after 15-18 da of storage; Shank and Lundquist (1963) reported a mild acid taste after 21 da of storage; and Pierson et al. (1970) reported a slightly sour flavor after 10 da.

Griffin et al. (1982) reported no differences in tenderness or juciness of beef loin steaks as storage time increased regardless of packaging type (oxygen permeable, medium oxygen barrier, high oxygen barrier). However, flavor ratings did change with storage time, temperature, and packaging material. Steaks were rated on an 8 point scale (8=extremely desirable, 1=extremely undesirable). Zero time scores averaged 5.7. Steaks packaged in oxygen permeable film were given acceptable flavor scores for all 6 da of the display life study. Vacuum packaged steaks from subprimals stored 0 or 12 days before fabrication did not change in flavor acceptability until 20 and 15 da for medium oxygen barrier and high oxygen barrier films, respectively. They concluded that overall palatability was greater for steaks displayed at $2^{o}C$ (as compared to $7^{o}C$) and for steaks vacuum packaged in high oxygen barrier film (as compared with medium oxygen barrier films) although results were not different ($P>.05$).

Pierson et al. (1970) evaluated flavor scores for anaerobically packaged and MSAD80 cellophane packaged steaks (5=excellent, 1=unacceptable). A fresh round was used as a control each day, and was given high ratings consistently. The score for aerobically packaged beef decreased steadily. At day four it had an off flavor; by day seven it was "totally unacceptable". Anaerobically packaged samples were given slightly lower scores than the control, but not until days 10 and 15 of storage. A slight sour flavor was noted on these

sampling dates.

Jaye et al. (1962) used the same 5 point scale to evaluate ground beef samples from fresh beef trim. Control samples were consistently rated good. Cellophane wrapped samples became progressively inferior each day until day six at which time they were judged putrid and evaluations were terminated. Anaerobic saran-packaged samples were noted to have a sightly sour taste after 8 and 10 da of storage. They inferred from these results that the sour off flavors resulting from anaerobically packaged beef are preferable to the putrefaction of cellophane packaged beef, and that a definite preference was shown for saran packaged as compared with cellophane packaged beef.

An eight member trained panel was used to evaluate the tenderness, juiciness, and flavor desirability of steaks cut from beef knuckles (subprimal cuts). No changes in tenderness due to storage time (0-35 days) or degree of vacuum (low, medium, high) were found. Juiciness was not consistently affected by either degree of vacuum or display time. Flavor desirability was not affected by either degree of vacuum or length of storage (Seideman et al., 1976c).

Causes of Off Flavors: Most studies have related the undesirable flavors of vacuum packaged beef to microbial growth., According to Seideman et al. (1976c) and Cantoni and Bolther (unpublished study), 200-300 million Lactobacilli/gram are the maximum number tolerable without organoleptic changes occurring. Seideman et al. (1976c) concluded that since the storage intervals in their study were "relatively short" and no significant changes in flavor ratings occurred, numbers of lactobacilli did not reach this 200-300 million level.

Pierson et al. (1970) attributed the slightly sour flavor of stored vacuum packaged beef to the slow development of lactic acid bacteria. The putrefaction of aerobically packaged beef was attributed to the presence of Pseudomonas-Achromobacter bacteria. Souring of saran wrapped beef after 15-18 da of storage was also attributed to lactic acid bacteria by Jaye et al. (1962). Johnson (1974) reported that sour or cheesy flavors in vacuum packaged beef are caused by microbial activity.

Egan and Grau (1981) inoculated fresh beef with Brochothrix thermosphacta, vacuum packaged and stored it at 5°C. They reported rapid spoilage of the beef due to the development of "off" flavors and aromas. Egan and Shay (1982) used a 14 member trained panel to evaluate beef biceps femoris inoculated with psychrotrophic lactic acid bacteria. Nine point scales (0=none, 8=very strong) and (0=very poor, 8=very good) were used to evaluate off flavors and overall acceptability, respectively. They reported that vacuum packaged Lactobacillus inoculated samples became different ($P<.01$) from the controls after 24 da of storage for both flavor and acceptability. When films of different permeabilities were compared, using uninoculated samples, they found the samples wrapped in more permeable films deteriorated more rapidly. The highest oxygen barrier film ($1 cm^3/m^2/24hr/atm$) samples did not develop off flavors throughout the 27 da storage study. When samples were inoculated with Lactobacillus and Leuconostoc, off flavors developed throughout the storage period, becoming significant after 35 da. The off flavor was characterized as sour, acid, bitter and "liver-like" by the taste panel. Because of the dependence of spoilage rate on film permeability, they concluded that oxidative rancidity is involved in the spoilage of vacuum packaged beef. They suggested that vacuum

packaged beef has an "ultimate" shelf life, since the meat does spoil, even if sterile.

Compared with results of an earlier study, they concluded that lactic acid bacteria are less important in meat spoilage than B. thermosphacta (Egan et al., 1980) when films of relatively high permeability are used. And, recently, Grau (1983) found that B. thermosphacta grows more rapidly on fat than on lean surfaces of vacuum packaged chilled beef.

ODOR

Although off odor development in vacuum packaged meat is not believed to be a major limitation to display life (Breidenstein, 1982), many studies have commented on the sour, lactic, cheesy, milky, and butyric off odors often associated with vacuum packaged beef (Grau, 1978; Hanna et al., 1979). These odors are attributed to volatile fatty acids some of which are produced by heterofermentative lactic acid bacteria (Agricultural Research Council, 1974-75; Sutherland et al., 1976). Studies have shown that beef stored in high oxygen barrier film has a lower tendency to develop off odors than beef packaged in medium or low oxygen barrier films (Egan and Shay, 1982; Griffin et al., 1982; Hanna et al., 1983).

The putrid odors of aerobically packaged steaks are attributed to Pseudomonas spp. and Achromobacter spp bacteria (Taylor, 1982). Pierson et al. (1970) found the odor of anaerobically packaged round steaks to be comparable to that of freshly cut control round steaks throughout the 15 da display study.

They attributed this to the slow development of lactic acid bacteria. Their results agree with those of Jaye et al. (1962). They noted no off odors in ground beef at 12 da of storage with saran wrapped samples, and a putrefactive odor in cellophane wrapped samples at six days.

Hydrogen sulfide odors, occurring most frequently in meat with a pH of 6.0 or higher, are frequently attributed to pseudomonas ssp. growth (Nicol et al., 1970; Johnson, 1974). Bacteria were unable to produce hydrogen sulfide at a lower pH. Patterson and Gibbs (1977) reported a "slight pickles" odor when meat of a high pH (above 5.5) was inoculated with H alvei. No off odors were detected when meat with a pH of 5.4-5.5 was inoculated.

Hanna et al. (1979) investigated hydrogen sulfide and "sour" odors in commercially vacuum packaged strip loin steaks. Microbial analysis predominately isolated lactobacillus (homofermentative L. plantarum and heterofermentative L. viradescens), Hafnia alvei, and Pseudomonas spp. colonies. Reinoculation of beef chuck steaks indicated that the heterofermentative Hafnia alvei most likely caused the hydrogen sulfide odors in the commercial steaks. These authors believe only a small portion of the odors to be caused by Lactobacillus.

In a later study, Hanna et al. (1983) attributed "sour", "buttermilk", "sulfur-like", and "H_2S" odors to lactic acid bacteria. Their results indicate that round steaks packaged in high oxygen barrier film deteriorated very slowly. Steaks inoculated with lactic acid bacteria were given lower off odor scores (more odor) than uninoculated samples, but only in a few instances were the differences significant. Their results agree with those of Egan and Shay (1982) who found deterioration of steaks packaged in low oxygen permeable films was

mainly due to off flavors, not off aromas.

SENSORY EVALUATION

Sensory evaluation is defined as "a scientific discipline used to evoke, measure, analyze and interpret reactions to those characteristics of foods and materials as they are perceived by the senses of sight, smell, taste, touch, and hearing" (IFT, 1975). It can be used in many ways: for new product development, product matching, product improvement, process change, cost reduction and/or selection of a new supplier, quality control, storage studies, product grading or rating, consumer acceptance, consumer preference, panelist selection and training, and correlation of sensory with chemical and physical measurements.

Sensory evaluation can be divided into two groups, analytical and affective. Analytical testing evaluates products in terms of differences or similarities and may identify and quantify a product's characteristics. Affective tests measure acceptance and/or preference.

Triangle Testing: Triangle testing is an analytical-discriminative test. It measures whether or not a difference can be detected at a predetermined significance level. Three coded samples are presented to the judge, two identical and one different. The judge is asked to identify the different sample.

Preference Testing: Once it has been established that a difference exists between two products (via triangle testing or other means),

preference/acceptance testing can be used to measure relative preference/acceptance. Hedonic scoring for preference evaluation is used by 57% of the 56 major food companies recently surveyed by Brandt and Arnold (1977). The word hedonic relates to states or degrees of pleasantness or unpleasantness (McGill, 1979). "Hedonic" is now used to describe any type of affirmative scale. The absolute values obtained from these scales have little value; it is the relative and intra-test relationships that provide valuable information.

Flavor Profiling: Descriptive analysis is the discrimination and description of a product's qualitative and quantitative characteristics by a trained panel of 5-10 judges (Civille, 1979). One of the most popular descriptive methods is the flavor profile. It was developed in the 1940's by Arthur D. Little, Inc. as a means of answering questions for the Upjohn Company and the Ac'cent Division of International Minerals and Chemical Corporation (Little, undated). In 1949, Cairncross and Sjöström officially introduced this method to the public (Caul, 1957; Little, undated).

The purpose of flavor profiling is to "record a reproducible flavor analysis in which all the flavor components can be considered in proper perspective" (Caul, 1957). It defines differences, similarities and likenesses between products. There are five dimensions to the flavor profile: 1) aroma and flavor character notes 2) their intensities 3) order of appearance 4) aftertaste and 5) amplitude (Caul, 1957; Civille, 1979).

Character notes qualitatively describe a product's flavor and aroma. They include aroma components: sensations perceived by sniffing odors via the

olfactory nerve (i.e., musty, beefy); feeling facotrs perceived by nasal tactile nerves (sting); and flavor components: sensations perceived by odors when food or drink is in the mouth and then swallowed (musty, beefy, nutty), taste sensations initiated through the taste buds (sweet, sour, salty, bitter), mouthfeel sensations perceived by the mouth's tactile nerves (metallic, drying, salivating), and aftertaste sensations present after swallowing, which includes all of the above (Caul, 1957).

Intensity refers to the degree to which a character note appears in the sample and is a quantitative measure. Several different scales have been developed; all evaluate a characteristic from none to strong. Character notes are generally reported in their order of appearance. If exact order cannot be determined, characteristics can usually be classified as appearing early, middle, or late (Civille, 1979). Aftertastes are those characteristics that are noted after swallowing. Many times they are long lasting. Usually only one or two aftertastes are found in a product. Intensities are not usually assigned (Caul, 1957).

The final attribute, amplitude, is a measure of the blendedness and appropriateness of a product's characteristics. This is an overall rating, done before scaling the individual attributes. Overall impressions are difficult to compare with consumer data, since they may not reflect consumer preferences (Civille, 1979).

Panelists with average tasting ability are selected for flavor profiling. They are trained to discriminate (detect a product's characteristics), describe and quantify the characteristics. The training process is long and involved, but once trained in the flavor profile method, panelists can efficiently be trained

for specific products.

Once a panel is trained, they can begin product analysis. First, the panel establishes a frame of reference using several similar products and raw materials included in the frame. Panelists discuss appropriate terminology so that each understands the product characteristics in the same way. A ballot or response sheet is developed from these terms and panelists begin to practice analyzling samples. They give each characteristic an intensity rating. These scores are reported to a panel leader and discussed. Once it is determined that panelists are evaluating the products similarly, actual samples are presented in the same manner. The final profile can then be compared to another product's profile and the differences and/or similarities examined. Generally this data is not treated statistically (IFT, 1975; Civille, 1979).

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Chapter III

CONSUMER ACCEPTANCE OF VACUUM PACKAGED GROUND BEEF AS INFLUENCED BY PRODUCT COLOR AND EDUCATIONAL MATERIALS

ABSTRACT

Questionnaries were completed by 1750 grocery store shoppers to determine the effect for product color and educational materials on purchase intent of vacuum packaged (VP) ground beef. Consumers at nine Dillon's supermarkets in Salina, Hutchinson, and Wichita, Kansas participated. Each participant examined three ground beef packages, presented in a random order: a polyvinyl chloride (PVC) packaged sample in the bright cherry red oxymyoglobin pigment form; a PVC packaged sample in the brown metmyoglobin pigment form; and a VP sample in the purple-red reduced myoglobin pigment form. Half the consumers received product information (informed). Informed consumers were more likely ($P<.0001$) to indicate a positive purchase intent for VP ground beef than uninformed consumers. Purchase intent for bright cherry red PVC packaged ground beef was lower ($P<.0001$) for informed consumers than for the uninformed group. Educational materials did not appear to have an effect ($P>.10$) on purchase intent for brown PVC packaged ground beef. Informed consumers were as likely to purchase the purple-red VP product as the bright cherry red product they are accustomed to purchasing. Consumers (74%) indicated that color was important in their product purchase intent decision. Color (35%) and amount of fat (38%) were the two most important single factors to the participants when selecting ground beef. VP ground beef should compete

favorably if educational materials are utilized.

Introduction

It is generally accepted that vacuum packaging of beef can potentially extend display-life, reduce product loss and lower transportation and delivery costs. The oxygen permeability of polyvinyl chloride (PVC) packaging enhances formation of the familiar bright red oxymyoglobin pigment followed by oxidation to the undesirable brown metmyoglobin pigment within 5 days at 3.3°C (Pierson et al., 1970). Without oxygen, as with vacuum packaging, the purple-red reduced myoglobin pigment is formed and persists throughout the product's display life (Pierson et al., 1970; Griffin et al., 1982). However, it is not known if the consumer can learn to accept the purple-red color of vacuum packaged (VP) beef products.

Consumers, used to buying bright red meat, associate this color with good quality (Tuma et al., 1973; Smith, 1981; Taylor, 1982; Reynolds, 1983). When selecting beef, consumers indicated meat color as the most important factor (Koudele et al., 1983). This may be because parents teach children to choose meat with a bright red color (Smith, 1981). Although the discrimination is unfounded, consumers are suspicious of any muscle color abnormalities (Romans and Ziegler, 1977). The idea of bright red color being good has hindered the introduction of vacuum packaging.

Few studies have focused on consumer reaction to VP beef. Small scale testing in Minnesota indicated that consumers did notice a difference between VP and PVC packaged beef, but did not react adversely (Ernst, 1980; O'Neill, 1981). However, VP and PVC products were not displayed side by side. Many believe consumer education is the key to VP beef's success (Kropf, 1980; Ernst, 1980; Smith, 1981; Taylor, 1982).

Since consumer acceptance is needed for product success, consumer

studies provide a useful tool for estimating product marketability (Morse, 1951). One type of consumer study involves on-the-spot interviewing of consumers as to their perceptions of the product. The basic rationale of this central location testing is that information can be collected under controlled conditions, equipment and testing space can be made available, personnel required are relatively few, and the psychological environment can be controlled (American Society for Testing and Materials, 1979).

The objective of this research was to determine consumer response to VP ground beef via central location testing. Consumer responses were evaluated to measure the influence of color on acceptability, and if acceptability can be increased by a well designed consumer information program regarding VP ground beef.

Materials and methods for this study were based on those used for a preliminary study in Manhattan, Kansas in March, 1984 (Appendix 1).

Materials and Methods

Sampling Design

Questionnaires (Appendix 2) were distributed to 1750 grocery store shoppers by 12 interviewers. Consumers at nine Dillon's supermarkets in Salina, Hutchinson and Wichita, Kansas were study participants. Three store locations in each city were chosen to obtain a cross section of each city's grocery store shoppers. Sampling was accomplished on 6 days in August, 1984 between 8:00am and 7:00pm. Pairs of interviewers were randomly assigned to grocery stores.

Every third adult approaching the meat counter was asked to participate in the study. The approach was: "Hello, I am a student at Kansas State University. We are doing a study on consumer ground beef preferences and would like you to participate. We have three products for you to look at and a questionnaire to fill out. It will take about 5 min. We would really appreciate it if you could take a few minutes and help us out." Each participant examined three ground beef packages, presented in a random order: a PVC packaged sample in the bright cherry red oxymyoglobin pigment form, a PVC packaged sample in the brown metmyoglobin pigment form and a VP sample in the purple-red reduced myoglobin pigment form. These consumers then completed self-administered questionnaires. Educational materials (Appendix 3) explaining the benefits and appearance of VP beef were presented to 50% of the study participants. Participants with even numbered questionnaires received educational materials. Odd numbered questionnaire recipients were uninformed.

Questions asked dealt with purchase intent for the three displayed

products (reduced myoglobin, oxymyoglobin, metmyoglobin); the observed differences among the three products, the similarity of apparent fat content and packaging of the three products, the influence of fat content and color on the purchase intent for the three products, buyer behavior characteristics (frequency of grocery shopping, frequency of purchasing beef, quantity of beef purchased, influence of ground beef prices, packaging, and fat content on beef purchase decisions, and the most important factor when selecting ground beef); freshness and quality equality between purple-red and bright red ground beef, willingness to purchase and/or pay the same price for purple-red and bright red ground beef, and demographic characteristics (age, sex, education, occupation, income, household type).

Sample Preparation

Beef trim from steer carcasses was obtained from the Kansas State University meat laboratory facility. Samples were coarse ground (1.27cm plate) and fine ground (.32cm plate). Fat content was standardized at 16±2% using the Hobart Fat Analysis apparatus. Fat was fine ground and mixed with the coarse ground lean trim to ensure even fat distribution when fine ground. Immediately after fat standardization, samples were packaged in 400±5g units and stored for the appropriate time prior to testing. Beef for the metmyoblobin samples was ground and PVC packaged 4 to 8 da preceding the test. Samples were wrapped with PVC film and heat sealed. To create the metmyoglobin pigment, packages were subjected to intense lighting (200 foot candles) for 12 to 24 hr at 23°C, and then were stored in the dark at 1°C until tested. Oxymyoglobin samples

were ground 24 to 48 hr before testing, wrapped with PVC film, heat sealed and stored in the dark at 1°C until testing. Samples displaying the reduced myoglobin pigment had been vacuum packaged (Bi-vac) 2 to 5 da prior to testing with a high oxygen-barrier film of surlyn-saran (3.3 mil base, 5.2 mil top web) and stored in the dark at 1°C until testing.

Different oxymyoglobin and reduced myoglobin samples were used on each survey date; metmyoglobin samples were the same for the two consecutive days in each city, but were changed between cities. Extra samples for each date were prepared in order to obtain Hunter Color Lab (L, a, b, reflectance) readings. Measurements were taken concurrently with survey administration. Readings were also taken on samples after display to obtain a measure of pigment changes occurring during display.

Sample areas for evaluation were displayed through standardized rectangles (10 X 18cm) cut in white paper. This minimized package appearance differences which could interfere with product evaluations. Samples were displayed in open refrigerator cases with 968 to 2152 lux illumination (Table 1). Lighting intensity was measured on the surface of the displayed products.

Data were analyzed using SAS programs. Frequency distributions, chi-square analysis, analysis of variance and correlation coefficients were used to explain independent variable influences on the dependent variable (purchase intent for VP ground beef).

Table 1 - Display lighting conditions (top meat level) during sample evaluations at the nine supermarkets.

Store	Lighting type	Lighting intensity (lux)
1	incandescent spots GE lite white	452-646
2	incandescent spots regal white	1345-1506
3	incandescent spots	120-140
4	regal white	915
5	regal white cool beam	1614
6	regal white cool beam	1022
7	lite white	861
8	regal white	968
9	regal white	1184

Results and Discussion

Eighty-nine percent of the participants were over 24 years old. Eighty percent were female, the largest groups had either finished high school (35%) or had some college education but no degree (30%). Forty-three percent were unemployed, 14% were retired, the remainder had a variety of occupations. Each income level included 8 to 16% of the respondants. Most participants were married (77%); 48% had children (Table 2). Seventy-nine percent purchase groceries at the survey store once a week or more, 68% purchase beef with the same frequency (Table 3).

These demographic and buyer behavior characteristics, shown in Tables 2 and 3, did not appear to greatly influence purchase intent for VP ground beef of either the informed or uninformed group. Of those consumers given product information, income was the only demographic or buyer behavior characteristic that affected purchase intent of purple-red ground beef ($P<.01$). LSD and Duncan's Multiple Range mean separation indicated that consumers with incomes under $5,000 were less likely to purchase the purple-red product (3.9 mean value) than all other income levels (2.9 to 3.3 mean value)(1=very definitely would purchase, 4=may or may not purchase, 7=definitely would not purchase). This may be because people of lower income levels have a smaller disposable income and may be less willing to risk dissatisfaction with a new product. Higher income persons may be more willing to try a new product because its cost will not usually prevent them from purchasing those items they need. Thus, they are not risking as much.

Uninformed consumers did not differ in their purple-red product purchase

Table 2 - Demographic characteristics frequency distribution

Characteristic	Frequency (percentage)	N
Age		
less than 18	2.0	
18-24	9.5	
25-34	18.5	
35-44	19.7	1677
45-54	16.3	
55-64	17.8	
65 and over	16.2	
Sex		
male	19.5	1678
female	80.5	
Educational Level Completed		
grade school/middle school	4.7	
high school	35.2	
vo-tech	2.9	
some college	30.1	1668
college graduate	16.7	
graduate school	10.4	
Occupation		
not employed	42.9	
student	3.8	
educator	6.6	
laborer	6.9	
professional	8.2	1567
administrative	3.6	
service	6.7	
clerical/sales	14.0	
other	7.3	
Income		
less than $5,000	8.3	
5,000-9,999	9.5	
10,000-14,999	10.9	
15,000-19,999	10.2	
20,000-24,999	15.0	1507
25,000-29,999	12.3	
30,000-39,999	15.9	
40,000-49,999	8.5	
50,000 and over	9.4	
Household		
young, single	10.9	
young, married, no children	4.7	
young, married, youngest child < 6	16.4	1645
married, youngest child > 6	31.2	
older, married, no children	24.4	
older, single	12.4	

Table 3 - Buyer behavior characteristics frequency distribution

Characteristic	Frequency (percentage)	N
How often shop at location		
more than once a week	49.5	
once a week	29.6	
once every two weeks	10.0	1703
once a month	4.8	
rarely	6.1	
How often purchase beef		
more than once a week	26.2	
once a week	41.6	
once every two weeks	15.6	1701
once a month	8.1	
rarely	8.5	
How much beef purchased at a time		
less than 5 lbs.	55.8	
more than 5 lbs but less than 10 lbs.	31.8	
more than 10 lbs but less than 20 lbs.	7.1	1706
20 lbs or more	5.3	
Prices influence ground beef purchase decision		
very strongly agree	25.0	
strongly agree	21.1	
slightly agree	25.4	
no opinion	5.6	1702
slightly disagree	8.6	
strongly disagree	7.6	
very strongly disagree	6.7	
Fat content influences ground beef purchase decision		
very strongly agree	23.8	
strongly agree	35.7	
slightly agree	14.6	
no opinion	2.5	1709
slightly disagree	3.5	
strongly disagree	8.1	
very strongly disagree	11.8	
One factor mst. imp. when selecting ground beef		
package appearance	7.6	
amount of fat	37.6	
total price of package	6.8	1705
price per pound	12.8	
color of beef	35.2	
Packaging influences ground beef purchase decision		
very strongly agree	14.0	
strongly agree	22.0	
slightly agree	33.9	
no opinion	12.1	1707
slightly disagree	9.0	
strongly disagree	5.0	
very strongly disagree	4.0	

intent on the basis of demographic variables. However they did differ on the basis of some buyer behavior characteristics ($P<.05$). Uninformed consumers who saw fat to be the major difference among the three displayed products were more likely to indicate a positive purchase intent for the purple product (3.1 mean purchase intent vs. 3.7-4.2 mean purchase intents) than those indicating any other difference. However, only 8% of the uninformed consumers indicated that fat was the difference between the products. Uninformed consumers who chose color of beef or total price of package as the most important factor in their ground beef purchase decision were less likely to indicate a positive purchase intent for the purple-red product than those indicating package appearance as the most important factor (4.0-4.1 mean purchase intent vs. 3.4-3.8 mean purchase intent).

Store within a city, and day and store within a city did not affect ($P>.05$) purchase intent of purple-red ground beef indicating that lighting differences between the stores did not explain differences in purchase intent. These findings are somewhat in disagreement with those of Hood and Riordan (1952) who reported that less discrimination towards discolored beef might be found in a store where the meat is not as brightly lighted. We found no difference in purchase intent for brown colored ground beef regardless of store (i.e., lighting differences).

Time of survey and surveyor did not affect purple-red ground beef purchase intent, ($P>.05$). However, order of sample presentation and day of survey within a city did affect the purchase intent of the purple-red product ($P<.0001$). Analysis of variance and subsequent mean separation indicated that consumers were less likely to indicate a positive purchase intent for purple-red

ground beef when the bright cherry red product was seen first, followed by purple-red and brown, respectively than when the products were seen in any other order. Participants who viewed the products purple-red, bright cherry red, then brown, were more likely to indicate a positive purchase intent than those viewing the products brown, purple-red, bright cherry red; purple-red, brown, bright cherry red, or bright cherry red, purple-red, brown. All other orders were equal. These results suggested that consumers may base their product decisions on other products they have already seen, although a definite pattern is not evident in this study. (Table 4)

Day of survey within a city also had an effect on purchase intent for purple-red ground beef ($P<.05$). Consumers on the first day in Hutchinson were more willing to purchase purple-red ground beef than participants on any other day within a city (3.2 mean value vs. 3.5-3.7 mean value).

Hunter Color Lab L, a, and b readings indicated that reduced myoglobin samples did not change much during display, the a and b values of the oxymyoglobin (PVC) samples generally dropped slightly, and the metmyoglobin samples did not change much. The oxymyoglobin samples became less red and less yellow. However, these changes were small and it is unlikely that these differences were perceiveable to the study participants (Table 5).

Consumers who received educational materials were more likely ($P<.0001$) to indicate a positive purchase intent for VP ground beef than uninformed consumers. (3.1 vs. 3.8 mean purchase intent score for informed vs uninformed consumers, respectively) Purchase intent for bright cherry red PVC packaged ground beef was lower ($P<.0001$) for informed consumers than for the uninformed group. Educational materials did not appear to have an effect

Table 4 - Purchase intent for purple-red ground beef as influenced by order of sample presentation

Order of Sample Presentation	Mean Purchase Intent for Purple-Red Ground Beef[d]
Bright cherry red/purple-red/brown	4.0[a]
Purple-red/brown/bright cherry red	3.6[b]
Brown/purple-red/bright cherry red	3.5[b]
Bright cherry red/brown/purple-red	3.4[bc]
Brown/bright cherry red/purple-red	3.3[bc]
Purple-red/bright cherry red/brown	3.2[c]

[abc]means with same letter superscript are not different (P .05)

[d]scale for purchase intent scores

1=very definitely would purchase
2=definitely would purchase
3=probably would purchase
4=may or may not purchase
5=probably would not purchase
6=definitely would not purchase
7=very definitely would not purchase

Table 5 - Hunter Color L, a, b mean readings by city before and after display for reduced myoglobin, oxymyoglobin and metmyoglobin samples

		Reduced Mb		Oxymyoglobin		Metmyoglobin	
		before	after	before	after	before	after
	Salina	39.3	35.7	40.7	36.4	--	43.1
L	Hutchinson	35.2	37.9	36.8	38.7	--	44.4
	Wichita	37.9	36.6	39.5	36.3	38.0	36.3
	Salina	20.2	24.1	25.0	26.2	--	14.3
a	Hutchinson	24.7	24.1	28.8	20.9	--	11.7
	Wichita	22.0	22.1	30.6	24.4	12.7	11.3
	Salina	2.8	4.1	7.1	7.2	--	7.2
b	Hutchinson	3.7	4.2	7.8	6.4	--	6.7
	Wichita	3.4	3.6	7.6	7.0	6.0	6.2

(P>.10) on purchase intent for brown PVC packaged ground beef (Table 6). Hood and Riordan (1952) indicated that 6 factors are important in a consumer's selection of a particular package of meat from a self-service display. They are 1) degree of discoloration (influenced by lighting conditions, absolute level of discoloration, current views on discoloration and the sample of consumers used in the study); 2) actual meat color intensity, hue, and brightness; 3) physical characteristics (especially degree of 'drip'); 4) other factors such as weight or price of package, amount of fat, lean or bone; 5) condition of the package; and 6) position of the package on the rack.

Mean purchase intent scores for bright cherry red, purple-red and brown colored ground beef were 3.0, 3.1, and 5.6 respectively for informed consumers; 2.6, 3.8 and 5.6 respectively for uninformed consumers (1=very definitely would purchase, 7=very definitely would not purchase). These means suggested that informed consumers were as willing to purchase VP ground beef as the bright cherry red product they are accustomed to purchasing. They would probably purchase either product. Uninformed consumers indicated a difference in their willingness to purchase purple-red VP and bright cherry red ground beef. They indicated they would probably/definitely purchase the bright cherry red PVC packaged product and may or may not purchase the purple-red VP packaged product. Both groups agreed that they probably/definitely would not purchase the brown PVC product.

Consumers who received educational materials which indicated that the brown colored beef was less fresh than either bright cherry red or purple-red beef were no less or more willing to purchase the brown ground beef than the uninformed consumers. This may be because consumers already associate the

Table 6 - Bivariate percentage table of willingness to purchase purple-red, bright cherry red, and brown ground beef by informed and uninformed consumers.

Category	Product	Purple-red		Bright Cherry Red		Brown	
	Consumer:	Informed	Uninformed	Informed	Uninformed	Informed	Uninformed
Very definitely would purchase		21.6	7.1	17.5	26.8	2.6	3.7
Definitely would purchase		14.9	8.0	17.2	19.5	2.3	1.8
Probably would purchase		24.9	27.0	35.4	33.5	4.9	4.9
May or may not purchase		18.4	29.1	17.8	10.8	9.5	9.0
Probably would not purchase		10.5	16.6	6.9	4.3	20.7	21.8
Definitely would not purchase		4.2	5.4	2.5	1.4	18.5	18.2
Very definitely would not purchase		5.5	6.8	2.7	3.7	41.5	40.6
		N=860	N=869	N=861	N=872	N=860	N=868

brown product with loss of freshness and undesirability.

The mean purchase intent scores may support the hypothesis that consumers associate color with freshness and that color influences their purchase intent. Consumers (74%, data not shown) agreed that color influenced their purchase decision of the three products. Color (35%) and amount of fat (38%) were the two single most important factors to the participants when selecting ground beef (Table 3). These findings are in accordance with other researchers reporting leanness is the most important factor in meat purchase decisions followed by brightness of color (ASPC, 1964; Rhodes et al., 1955; Seltzer, 1955). Open ended narrative responses given upon examining the three products, indicated 'color' (52%) to be the major difference between them, with 'fat and appearance' (18%), 'fat' (12%), 'appearance' (5%), 'color and fat' (5%) and other factors (9%) following. Although it is not possible to statistically substantiate from this data, according to ASPC (1964), Rhodes et al., (1955) and Seltzer (1955), 'appearance' judgments are primarily based on brightness of color.

Sixty-six percent of the participants indicated that fat content was important to them in their purchase decision of the three products. Approximately half the consumers indicated that the fat content of the three products was similar (49%). Of those indicating that fat content was important in their purchase decision, 39% indicated that the fat content was not similar between the products although laboratory analysis showed that fat content was similar for each product. The remaining 61% either rated fat content unimportant in their product purchase decision and/or indicated that the fat content of the three products was similar. Although no formal questions were

asked to determine how the fat content of the three products varied, informal comments indicated the following: Brown colored ground beef appeared the most fatty of the three products. And, bright cherry red ground beef appeared least fatty. This may be because of the larger contrast between the brown lean and the white fat than between the bright cherry red lean and white fat. The larger contrast between purple-red lean and the fat also makes the VP product appear fattier than the bright cherry red product.

Summary

Many researchers believe that consumer education is necessary for the acceptance of VP beef (Kropf, 1980; Ernst, 1980; Taylor, 1982). This is due to the fact that VP beef has a purple-red color rather than the bright cherry red color consumers associate with good quality (Smith, 1981; Taylor, 1982). Color is probably the appearance factor that most determines if a package of meat will be purchased (Kropf, 1980; Ernst, 1980; Taylor, 1982).

We are not aware of other formal testing to determine the effect of both educational materials and color on purchase intent for vacuum packaged beef. This study supports research indicating that color is important to consumers when making purchase decisions. However, this data indicated that fat content was the single most important factor to consumers when selecting beef. Although different from the findings of Koudele et al. (1983), these results are understandable. Besides pricing, the current 'health and fitness' trend may have increased consumer awareness regarding fat content, making fat the most important factor to many consumers when making purchase decisions.

Study date, store, city and time of testing did not significantly affect purchase intent for VP ground beef. Demographic and buyer behavior characteristics did not greatly influence purchase intent. This would indicate that a single, well-designed consumer education program may be effective in the marketing of VP ground beef to all target market segments. Although these conclusions are statistically representative only of Kansas grocery store shoppers and other shoppers with similar characteristics, it is believed that this trend may be representative of the country as a whole.

Based on the results of this study, it may be possible to effectively educate the consumer to accept the purple-red color of VP ground beef.

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CHAPTER IV

FLAVOR AND AROMA INFLUENCES ON CONSUMER ACCEPTANCE OF POLYVINYL CHLORIDE VERSUS VACUUM PACKAGED GROUND BEEF

ABSTRACT

Vacuum packaged (VP) ground beef was compared to polyvinyl chloride (PVC) packaged product to determine if cooked flavor differences existed and to determine cooked flavor and raw aroma preferences. Beef trim from steer carcasses was ground and packaged 12 da and 3 da prior to testing for VP and PVC samples respectively. Triangle testing by untrained consumers indicated that the samples had a different ($P<.01$) beef flavor. Comments indicated that the VP sample was "fresher" tasting and did not have the "off notes" associated with the PVC sample. Degree of difference between the samples was slight. Subsequent preference testing indicated that untrained consumers preferred ($P<.01$) 3 da PVC ground beef over 12 da VP ground beef. Mean scores for the two products were similar, indicating that both products were "slightly" to "moderately" liked. Seventy percent of the participants would cook the VP product based on its raw aroma, 49% would cook the PVC product. The typical "sour" odor frequently associated with VP beef did not adversely affect the consumers' decision to cook the product. Based on flavor and aroma characteristics, VP ground beef should compete favorably in the marketplace.

Introduction

Vacuum packaging of beef offers many benefits to both the consumer and processor (Taylor, 1982). However, it is not well documented if these benefits extend to consumer preference for flavor and aroma. Little research has focused on consumer flavor and aroma comparisons of polyvinyl chloride (PVC) packaged beef (the conventional method for packaging retail units of beef) with vacuum packaged (VP) beef. Jaye et al. (1962) used a 5 point scale (5=excellent, 1=unacceptable) to evaluate cooked ground beef samples from fresh beef trim. They concluded that anaerobically packaged samples were definitely preferred to aerobically packaged samples after storage.

Flavor preferences for anaerobically packaged beef have been attributed to the difference in microbial flora. The slightly sour flavor of stored vacuum packaged beef has been attributed to the slow development of lactic acid bacteria (Pierson et al., 1970; Jaye et al., 1962). The less acceptable flavor of PVC packaged beef was attributed to the presence of putrefactive Pseudomonas spp. and -Achromobacter spp. bacteria.

Unlike flavor, off odor development is not thought to be a limiting factor in the display life of vacuum packaged meat (Breidenstein, 1982). The sour, lactic aromas that sometimes develop (Grau, 1978; Hanna et al., 1979) are attributed to volatile fatty acids produced in part by heterofermentative lactic acid bacteria (Agricultural Research Council, 1974-1975; Sutherland et al., 1976). Odors of aerobically packaged beef are thought to be caused by Pseudomonas spp. and Achromobacter spp. (Taylor, 1982).

One way of measuring if a flavor difference exists is triangle testing. It

is an accepted method for use in product development, matching and improvement, process change, cost reduction, quality control and storage stability testing (IFT, 1981). It is the method normally used in the industry and university research environment to determine if a difference exists between two samples (Fossum, 1983). Once a difference has been established, affective testing, such as preference testing can be used to measure acceptance and/or preference. Hedonic scales are the most common scales used for preference testing (Larmond, 1982).

The objective of this research was threefold: (1) to determine, by triangle testing, if untrained judges could differentiate between VP and PVC packaged cooked ground beef flavor, (2) to determine their flavor preference, via paired preference testing, and (3) to evaluate the acceptability of VP and PVC raw product aroma.

Materials and Methods

Vacuum packaged (VP) ground beef was compared with polyvinyl chloride (PVC) packaged ground beef to determine if detectable cooked flavor differences existed, and if so, which product was preferred. Acceptance of raw product aromas was also evaluated. Based on display life information (Kastner, 1984), 3 da (PVC) and 12 da (VP) display times were selected for product age at the time of testing. These display times are believed to reflect typical storage times prior to consumer purchase and consumption. Triangle testing determined the existence of a flavor difference. Affective testing was used to evaluate consumer likes/dislikes and acceptability of raw product aroma.

Sample Source, Packaging, and Storage

Triangle Testing

Beef trim from steer carcasses was obtained within 48 hr postmortem from the Kansas State University meat laboratory facility. Samples were coarse ground (1.27 cm plate), fat content adjusted to 18% fine ground (.32 cm plate) and packaged in 200g±5g units for the appropriate time prior to testing. Samples were stored in the dark at 1°C for the entire period before testing. Vacuum sealed samples were ground and packaged in high oxygen-barrier, r mil nylon bags with polysealant 12 da prior to testing using a Smith Super Vac. Vacuum was 711mm Hg. At the same time, trim for PVC samples was vacuum packaged in 4.5 kg units. Three da prior to testing that trim was ground and PVC packaged.

Preference Testing

Samples were prepared in a manner similar to that for triangle testing except for the following variations. Trim for PVC packages was coarse ground concurrently with the product for VP samples. It was then vacuum packaged in one large unit and stored at 1°C. After 9 da it was fine ground and placed in oxygen permeable bags. Once the meat received its final packaging, it was displayed (-2.0 to 4.0°C) under continuous Natural fluorescent lighting (100 foot candles, 1076 lumen/m^2) in a commercial type display case. Temperature fluctuated due to the cycling of the case and twice daily defrosting. Packages for raw product aroma evaluation contained 100g±5g of ground beef, flavor sample packages contained 200g 5g. All samples were adjusted to 18% fat.

Cooking and Sample Presentation

Samples for flavor evaluations were prepared in accordance with AMSA "Guidelines for Cookery and Sensory Evaluation of Meat" (1978). Uniform patties were formed by shaping 75.0g±.5g of ground beef in standard size disposable Petri dishes. After forming, samples were pan broiled at 171°C in electric skillets. Separate skillets were used for VP and PVC samples, insuring no intermingling of flavors. Patties were cooked 4 min on each side, cut into eight wedges, and served immediately on white paper plates. Panelists were seated in partitioned booths. Red lighting minimized appearance variations. Panelists were instructed to rinse their mouths with deionized water between samples, to place the entire sample in their mouths and to evaluate beef flavor only. Participants were volunteers from the Department of Animal Sciences and Industry (faculty,

staff and students).

Triangle Testing

Fifty-eight untrained judges (42 male, 16 female) evaluated the cooked products. Three to eight judges were used per session. Sessions were limited to eight judges to help prevent product temperature fluctuations.

Samples were presented in random order (Appendix 4) and panelists were first asked to select the different sample. Then they were asked to indicate the size of the difference and to comment on the difference (Appendix 5). Binomial distribution tables (Roessler et al., 1948) indicated the significance of the difference. Degree of difference results were averaged to determine size of perceived differences.

Preference Testing

Fifty-three untrained judges (36 male, 16 female) participated. First, cooked samples, one VP and one PVC, were presented in random order and judges were asked to indicate how much they liked or disliked the beef flavor of each of the samples (1=dislike extremely, 8=like extremely) (Appendix 6). After completing this phase of the test, each judge was given two packaged raw samples (one VP and one PVC) in a random order. Judges slit the package with a razor blade, brought the package to their nose and sniffed. They then indicated (yes or no) if they would prepare and eat the product based on its raw aroma. They also indicated whether or not they usually smelled ground beef before preparing it. Flavor preference results were analyzed using a paired

t-test. Mean like/dislike scores were calculated. Percentages were calculated for raw aroma acceptability.

Results and Discussion

Flavor

Of the 58 judges participating in the triangle test, 42 correctly identified the different sample, indicating that the two samples had a different ($P<.01$) beef flavor. Examining the comments of the correct judges leads us to believe that the VP product was "fresher" tasting and did not have the "off notes" associated with the PVC samples. PVC samples were described as "tangy, bland, not as beefy flavored" and "off flavored" as compared to the VP sample. The correct judges found the degree of this difference to be sight, 2.9 mean value (5=very large difference, 3=slight difference, 1=no difference).

Subsequent preference testing indicated that consumers preferred ($P<.01$) the 3 da PVC packaged ground beef over the 12 da VP ground beef. Mean scores for PVC packaged and VP samples were 6.0 and 5.4 respectively. This indicates that both products were "slightly" to "moderately" liked. There was no consistency in comments made. Some panelists found the VP product to have "more flavor", others made this comment regarding the PVC packaged product. Comments made referring to the "sourness" of the VP product are in agreement with the findings of Pierson et al., (1970) and Jaye et al. (1962). They reported a slightly sour flavor after 8 and 10 da of vacuum packaged storage.

These findings do not support the work of Griffin et al. (1982) or Jaye et al. (1962). Griffin et al. (1982) concluded that overall palatability of VP beef loin steaks wea unacceptable after 10-15 da display at $2^{o}C$-$7^{o}C$. Jaye et al. (1962) stated that the sour off flavors resulting from anaerobically packaged

beef were preferred over the putrefaction of product displayed in oxygen permeable packaging.

There are several possible reasons for these discrepencies. Display conditions, display time, initial microbial load and packaging materials can play important roles in speed of product deterioration. Animal differences can also play a part in flavor characteristics, initial contamination, rate of deterioration, and possibly consumer preferences. The types of people evaluating the product may have preference differences. A trained panel would characterize a slightly "off flavor" as undesirable, whereas to the untrained consumer this characteristic may be typical of the products they consume and, thus, preferable. For this reason, it is important to use untrained panelists when determining preference or desirability.

Odor

Of those consumers indicating that they smell their ground beef before cooking it, 73% would be willing to cook the VP sample as compared to only 53% indicating they would cook the PVC sample. Of those consumers who do not smell their ground beef before cooking it, 65% would cook the VP samples, 44% would cook the PVC wrapped product. Seventy percent of the total would cook the VP product, 49% would cook the PVC product. The "typical, sour" odor frequently associated with vacuum packaged beef did not adversely affect the consumer's decision to cook the meat. In fact, those consumers familiar with the smell of ground beef were more likely to cook the vacuum packaged product than those not accustomed to evaluating the raw aroma.

These results support the work of Jaye et al. (1962) who reported no off odors in anaerobically packaged ground beef after 12 da of storage, whereas aerobically packaged samples developed putrefactive odors. This may occur because, without oxygen, lactic acid bacteria cause fixation of the amino compounds, the main putrefactive agents (Ingram, 1962). According to Taylor (1972), the sour odor of VP beef, caused by lactic acid bacteria, will not develop for approximately 2 mon at 1°C. Egan and Shay (1982) and Smith (1981) agree that spoilage of vacuum packaged beef is first attributable to off flavor development, then to off odor development. The bacterial actions responsible for this spoilage are not clearly understood. Although most studies report lactic acid bacteria are responsible for spoilage, Egan and Shay (1982) report that B. thermosphacta is more important. The odor of fresh vacuum packaged beef deteriorates very slowly, even when samples are inoculated with lactic acid bacteria (Hanna et al., 1983).

Summary

Consumer taste panels detected a slight difference in beef flavor between unseasoned meat patties prepared from VP and PVC packaged ground beef (18% fat) with most comments favoring the VP samples. Further preference evaluation indicated they liked the flavor of the PVC packaged product better than the VP product, but not by a large amount. Both mean values fell in the slightly/moderately like range. Based on the raw aroma from packaged samples, consumers would be more likely to cook the VP product. Based on flavor and aroma, VP ground beef should compete favorably in the marketplace.

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Chapter V

FLAVOR PROFILES OF VACUUM PACKAGED AND POLYVINYL CHLORIDE PACKAGED GROUND BEEF: A COMPARISON OF COOKED FLAVOR CHANGES OCCURRING DURING PRODUCT DISPLAY

ABSTRACT

Vacuum packaged (VP) ground beef was compared to polyvinyl chloride (PVC) packaged product to describe and quantify via flavor profiling the flavor changes occurring during display. Triceps brachii and infraspinatus muscles from steer, heifer and young bull carcasses were ground and packaged 1 to 5 da and 1 to 24 da prior to testing for PVC and VP samples, respectively. A seven member experienced flavor profile panel was further trained by the panel leader who was familiar with the products. Panelists were trained to observe and record the aromatics, basic tastes, mouthfeel and aftertastes, and their intensities as associated with cooked PVC and VP ground beef. After evaluation of a sample was completed, the panel members discussed their findings, in order to develop a word description of the product to supplement the scale score. VP samples displayed to 24 da had a more constant profile than PVC samples displayed to 5 da. The initial beefy, fresh impact of VP samples after 1 and 3 da display declined slightly during display. The beefy note became briefer and was replaced by a lingering sourness. Bloody/serumy notes changed to metallic/sharp notes after 8 da display. PVC samples lost their beefy, fresh, bloody/serumy notes quickly. After 3 da display, the samples were bland with a

threshold amount of stale. At 5 da display, beef identity of the PVC samples was very low as was freshness. Bloody/serumy was not detected and blandness was replaced by a lingering stale note. The descriptors which most effectively explained flavor differences between 3 da PVC and 8 to 15 da VP samples were: beefiness, freshness, stale/off, bloody/serumy, metallic/sharp, and sour taste, and metallic mouthfeel and aftertaste. In addition to all the above descriptors, fat flavor, oily and astringent mouthfeel, and oily and stale aftertaste helped describe the changes in the PVC products between 1 and 5 da display.

Introduction

The display life of vacuum packaged (VP) beef is increased as compared to oxygen permeable polyvinyl chloride (PVC) packaged beef due to the lower incidence of spoilage organisms in the vacuum packaged product (Baran et al., 1970; Pierson et al., 1970; Minks and Stringer, 1972; Hodges et al., 1974; Gill and Newton, 1978; Newton and Rigg, 1979). Pseudomonas predominate in PVC packaged beef (Kirsch et al., 1952; Ayres, 1960; Pierson et al., 1970; Brown and Hoffman, 1972; Vanderzant et al., 1982) and Lactobacillus on VP products (Ingram, 1962; Jaye et al., 1962; Ordal, 1962; Baran et al., 1970; Pierson et al., 1970; Seideman et al., 1976; Sutherland, 1975; Dainty et al., 1979; Vanderzant et al., 1982). The microbial differences create flavor differences in the products over time (Jaye et al., 1962; Shank and Lundquist, 1963; Pierson et al., 1970; Griffin et al., 1982). Off odors are also attributed to these microorganisms (Jaye et al., 1962; Pierson et al., 1970; Nicol, 1970; Johnson, 1974; Sutherland et al., 1976; Taylor, 1982; Hanna, 1983).

In the past, hedonic and rating scales have frequently been used to evaluate the flavor and odor of VP and PVC packaged samples (Jaye et al., 1962; Pierson et al., 1970; Seideman et al., 1976; Egan and Grau, 1981; Griffin et al., 1982). Most studies have used trained panelists to evaluate the acceptability and/or preference for these flavors and odors.

Flavor profiling is a sensory analysis method that "records a reproducible flavor analysis in which all flavor components can be considered in proper perspective" (Caul, 1957). It defines differences and similarities between products in terms of aroma and flavor character notes, their intensities, their

order of appearance, aftertaste and amplitude (Caul, 1957; Civille, 1979). A highly trained panel is used to characterize and quantify product characteristics rather than to give measures of preference/acceptance.

The objective of this study was to use a modified flavor profile analysis to develop a standard vocabulary for describing the flavor of VP and PVC packaged ground beef and also to identify and quantify the similarities and differences between the two products occurring during display.

Materials and Methods

PVC samples displayed for 1 to 5 da and VP samples displayed for 1 to 24 da were selected for testing. Differences resulting from length of display were examined. A previously trained flavor profile panel at the Kansas State University Sensory Analysis Center was further trained for the evaluation of these products.

Panel Training

A seven-member trained panel (Caul, 1957) was oriented by the panel leader, familiar with the products, to evaluate the aromatics, basic tastes, mouthfeel and aftertastes associated with cooked, unseasoned PVC and VP ground beef. Seven practice sessions, approximately one hr in length, enabled the panelists to develop and correctly use a descriptive ballot (Fig. 1). They tasted a wide range of ground beef samples to facilitate ballot development and proper use of the intensity scale (Fig. 2). Animal, fat level, display time, and packaging differences were used to create the range of practice samples. Initial practice sessions focused on characterizing product aromatics, mouthfeel, and aftertastes; later sessions, on quantifying these characteristics.

Sample Source, Packaging, and Storage

Triceps brachii and infraspinatus muscles from steer, heifer, and young bull carcasses were obtained within 72 hr postmortem from the Kansas State

Figure 1 - Flavor profile ballot for polyvinyl chloride and vacuum packaged ground beef

Name _____ Date _____

Aromatics	Taste 1	Taste 2	Taste 3
beefiness			
fat			
freshness			
stale/off			
bloody/serumy/ metallic/sharp			
dairy/milky			
other (please specify)			
Basic Tastes			
sweet			
sour			
bitter			
salty			
Mouthfeel			
oily			
metallic			
astringent/drying			
other (please specify)			
Aftertastes			
oily/fatty			
beefy			
stale			
astringent			
other (please specify)			

Figure 2 - Flavor profile intensity scale for polyvinyl chloride and vacuum packaged ground beef

0	not present
X X+	threshold
1- 1 1+	slight
2- 2 2+	moderate
3- 3 3+	strong

University meat laboratory facility. All carcasses were A maturity and ranged in weight from 286-430 kg. USDA yield grades ranged from 1.3-3.4 and USDA quality grade from Choice to High Standard (Appendix 7). Samples were coarse ground (1.27 cm plate), adjusted to 17±2% fat, fine ground (.32 cm plate) and packaged in 400±10g units for the appropriate time prior to testing. VP samples were packaged in 4 mil nlylon bags with polysealant (2.4cc O_2 permeability 645cm^2/24hr at 23°C and 0° relative humidity) using a Smith Super Vac (686mm Hg). PVC samples were wrapped in a single layer of PVC film and heat sealed.

Packaged meat was displayed (-2.0 to 4.0°C) under continuous GE Natural lighting (1076 lux) in a commercial type display case. Temperature fluctuated due to the cycling of the case during defrosting every 12 hr. Length of display after packaging was varied to determine the effect of display time on the product's flavor profile. Display times for PVC samples were 1, 3, and 5 da. VP display times were 1, 3, 8, 10, 12, 13, 14, 15, 22, and 24 da. This distribution of display times allowed for varying degrees of product freshness.

Cooking and Sample Presentation

Samples for evaluation were prepared in accordance with AMSA guidelines (1982). Uniform patties were formed by shaping 80.0g±.5g of ground beef in standard size (60mm X 15mm) disposable Petri dishes. After forming, unseasoned patties were pan fried at 171°C in an electric skillet. Patties were cooked 4 min on each side (well done), cut into 8 bite size wedges and served immediately on odor-free, taste-free, white china plates. Each sample was assigned a three digit random number to ensure neither the panelists or the

panel leader was aware of the product's identity. Panelists were seated in partitioned booths. They were instructed to rinse their mouth with deionized water and/or a bite of cracker between samples.

Sample Evaluation

Each panelist received three bite-size pieces of each sample. Each bite was cooked and served 4 min apart. Aromatic, basic taste and mouthfeel evaluations were accomplished during the first three chews of each bite. Aftertaste was evaluated after swallowing. After evaluation of a given sample was completed, the panel discussed their findings in order to develop a word description of the product to supplement the scale intensity score. Three samples were evaluated during each 1 hr session. Order of these three evaluations was randomized. At the end of each hr, the three samples were discussed in relationship to each other. Nine hr were needed to evaluate the samples.

Results and Discussion

PVC Flavor Profile

The 1 da sample (Fig. 3) was described as slightly/moderately beefy and less fatty than beefy. Threshold amounts of stale, sweet, sour and salty flavors, metallic and astringent mouthfeels, and beefy and astringent aftertastes were present. The sample had a slightly less than moderate degree of freshness.

The 3 da PVC sample (Fig. 3) was described as slighty beefy, slightly fresh and slightly stale. Beefiness was described as very brief and was preceded by a brief stale note. After 2 chews, the sample was described as "bland" and lacking flavor impact. Slightly greater than threshold amounts of sour, oily mouthfeel, and oily and beefy aftertastes were noted.

After 5 da display, the slight beefiness was very brief (Fig. 3). Staleness increased to moderate and lingered. Basic tastes, mouthfeels and aftertastes were generally at threshold levels.

Comparison of 1, 3, and 5 da PVC Samples

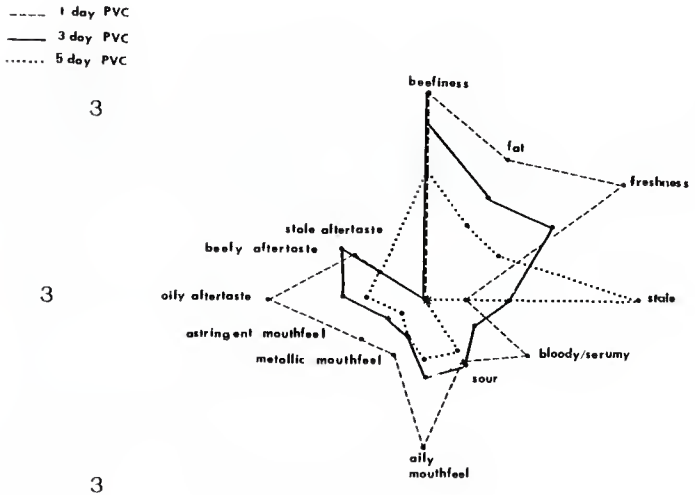
Flavor changes occurred during display of PVC wrapped samples (Fig. 4). Beefiness decreased with time. After 5 da, beefiness was evident at a slight level, as compared to a slight/moderate level after 1 da (Fig. 3). Supplementary panel comments indicated that duration of the beefy note became shorter as display time increased. A stale note took its place. The drop in freshness paralleled the drop in beefiness. Freshness declined from a moderate level at 1

Figure 3 - Flavor profile means for polyvinyl chloride packaged ground beef by flavor descriptor and display times

Flavor descriptor	Length of Display		
	Day 1	Day 3	Day 5
AROMATICS			
beefiness	2-	1+	1
fat	1	1-	)(+
freshness	2-	1	)(+
stale/off	)(	1-	2-
bloody/serumy/ metallic/sharp	1-	)(+	0
BASIC TASTES			
sweet	)(	)(	0
sour	)(+	)(+	)(+
salty	)(	)(	)(
MOUTHFEEL			
oily	1	)(+	)(+
metallic	)(+	)(	)(
astringent/drying	)(+	)(	)(
AFTERTASTES			
oily/fatty	1	)(+	)(
beefy	)(+	)(+	)(
stale	0	0	)(+
astringent	)(	0	0

)(=threshold
1=slight
2=moderate
3=strong

Figure 4 - Flavor profile thumbprint of 1, 3 and 5 da display polyvinyl chloride packaged ground beef mean scores

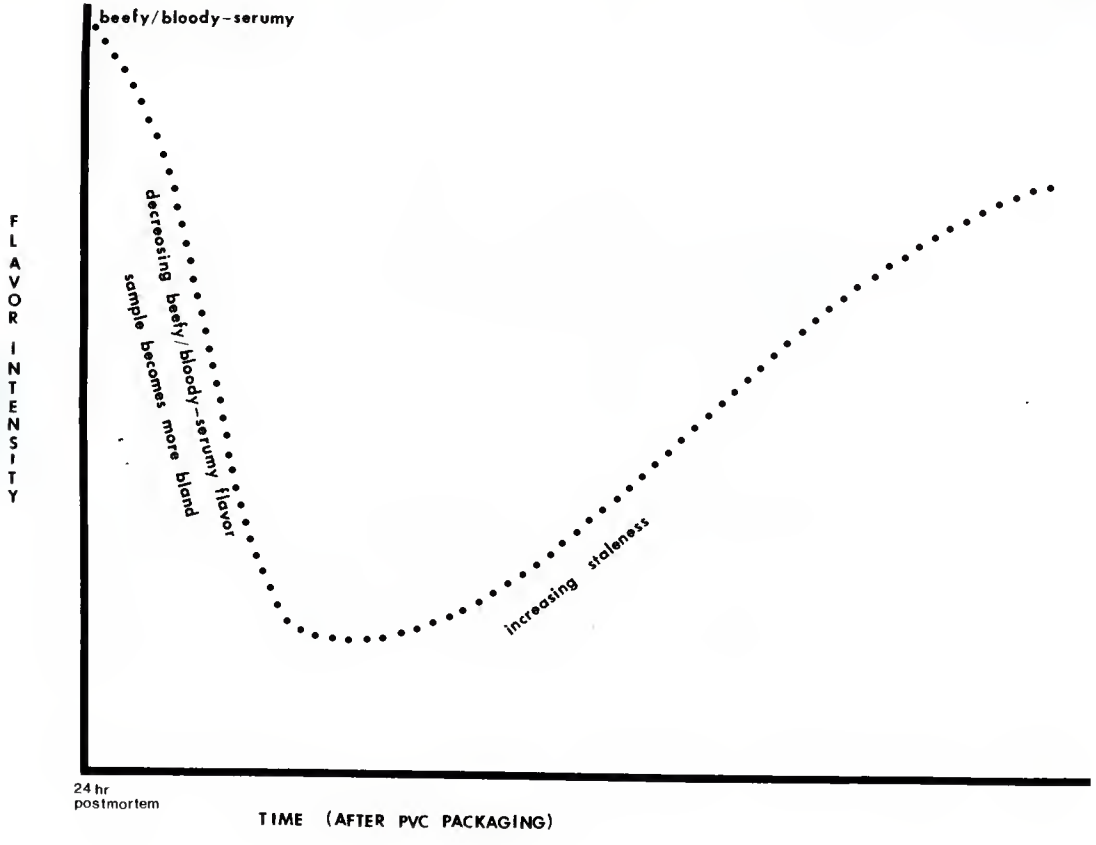

1 day PVC
3 day PVC
5 day PVC
beefiness
fat
freshness
stale
bloody/serumy
sour
oily mouthfeel
metallic mouthfeel
astringent mouthfeel
oily aftertaste
beefy aftertaste
stale aftertaste

da display to a threshold amount after 5 da display (Fig. 3). Staleness increased from 1-5 da. At 5 da the staleness lingered into the aftertaste. Fat flavor decreased with display time. At 1 da it was slight but decreased to 1- and)(+ after 3 and 5 da display, respectively. Bloody/serumy notes, slightly detectable after 1 da display, were present at a threshold level after 3 da and were not noted after 5 da. Metallic and astringent mouthfeels, sweetness, sourness, and saltiness generally remained at threshold levels during display. Oily mouthfeel declined slightly during display. Aftertastes were different after different lengths of display. After 5 da, beefy aftertaste dropped slightly and a stale aftertaste was noted. No other aftertastes were noted consistently (Fig. 3).

During practice sessions panelists noted that, 24 hr postmortem, freshly ground beef has a fresh, beefy, bloody/serumy flavor. Upon display, the beefiness was lost rapidly and freshness decreased. The beef became increasingly bland until a point at which stale notes began to develop and later the meat took on an "unpleasant" stale flavor. This beefiness loss/stale development is believed to follow the general curve in Fig. 5. During initial training and subsequent evaluations it appeared that PVC packaged meat followed this basic curve. The speed with which each sample progresses along the curve may be dependent on several factors such as animal differences, time postmortem before packaging, lighting, temperature of display, fat content, and initial microbial condition of the sample, etc.

Loss of beefiness and subsequent increase in stale flavors has been attributed to the growth of pseudomonads. These bacteria are psychro-tolerant and are believed to be responsible for the majority of the putrefactive surface spoilage of meats (Pierson et al., 1970; Brown and Hoffman, 1972). This

Figure 5 - Proposed time intensity curve for polyvinyl chloride packaged ground beef during display


beefy/bloody-serumy
decreasing beefy/bloody-serumy flavor
sample becomes more bland
increasing staleness
FLAVOR INTENSITY
24 hr
postmortem
TIME (AFTER PVC PACKAGING)

bacterial growth increases steadily from $10^3/cm^2$ at 0 da display to 10^6 to $10^7/cm^2$ at 5 da display at 3.3°C (Pierson et al., 1970).

Panelists detected a stale/off flavor as early as after 1 da display. This conflicts with the results of Pierson et al. (1970) and Jaye et al. (1962) who reported off flavors only after 4 and 4-6 da display respectively. Panelist sensitivity, display conditions, original condition and form of the product, sample preparation and scale type may help explain these discrepancies. Different cookery methods may result in flavor intensity differences. Berry and Leddy (1984) found fried ground beef patties had a more intense beef flavor than either microwaved or conventional oven roasted patties. McCormick et al. (1981) reported pan fried ground beef patties had more beef flavor than broiled patties. Jaye et al. (1962) found fresh rounds gave less dramatic changes in flavor than beef trim. They also noted a more rapid deterioration at storage temperatures of 3.3°C than at -1.1°C.

VP Flavor Profile

After 1 da vacuum packaging, the sample was fresh and beefy (Fig. 6). Panelists described a sour/metallic taste and mouthfeel, and a drying/sour note evident in the aftertaste. Threshold stale/off notes were detected.

The 3 da sample was similar to the 1 da sample. It was fresh and beefy. There were no stale notes and slightly less sour/metallic taste and mouthfeel. The metallic mouthfeel increased with chewing, but disappeared upon swallowing (Fig. 6).

Overall, the 8 da sample was similar to the 1 da and 3 da samples. No

Figure 6 - Flavor profile means for vacuum packaged ground beef by flavor descriptor and display times

	Length of Display								
Flavor descriptor	1	3	8	10	13	14	15	22	24
AROMATICS									
beefiness	2	2	2	2-	2	2-	2-	2-	1+
fat	1	1	1-	1-	1-	1-	1-	1-	)(+
freshness	2	2	2-	2-	2	1+	2-	2-	1+
stale/off	)(	0	0	)(	)(	)(	)(	)(+	1 *
bloody/serumy/ metallic/sharp	1	1	)(+	)(+	1-	1-	1-	1-	)(+
BASIC TASTES									
sweet	)(+	)(	)(	)(	)(	)(	)(	)(	)(
sour	1	1-	)(+	1	)(+	1-	1-	)(+	)(+
salty	)(	)(	)(	)(	)(	)(	)(	)(	)(
MOUTHFEEL									
oily	1-	1-	)(+	)(+	)(	)(+	)(+	)(+	)(+
metallic	1-	)(	)(+	)(+	)(+	)(+	)(+	)(+	)(
astringent/drying	)(	)(	)(	)(	)(	)(	)(	)(	)(
AFTERTASTES									
oily/fatty	1-	1	)(+	)(+	)(+	)(+	)(	)(+	)(+
beefy	1-	1+	1-	1-	1-	1-	1-	1	)(+
stale	0	0	0	0	0	0	0	)(	)(
astringent	0	)(	)(	)(	)(	)(	)(	)(	0
metallic	)(	0	0	)(+	)(+	)(+	)(	)(+	)(

* off note, other scores in row represent stale intensity

)(=threshold
1=slight
2=moderate
3=strong

significant changes were detected in beefiness or freshness. The bloody/serumy note present in the 1 da and 3 da samples, had decreased slightly and was described as metallic/sharp (Fig. 6).

At 10 da the sample was moderately beefy, but the beefiness was brief and was almost immediately replaced by a sourness which lingered throughout the evaluation. The sourness had metallic mouthfeel and left a metallic aftertaste. The sample did not have the beefy impact associated with the 1, 3, and 8 da samples. Stale notes were detected in only one 10 da sample, at a threshold level (Fig. 6).

By 13, 14 and 15 da (Fig. 6), beefiness decreased, but only very slightly compared to previous display times. Freshness also declined slightly. The sample was characterized by a short beefy note which was quickly replaced by sourness. However, the sourness was not as pronounced as in the 10 da sample.

The 22 and 24 da samples (Fig. 6) retained many character notes typical of 1 da VP ground beef, although, possibly at slightly different levels. One 24 da sample had an unfamiliar note characterized as "off". It was described as "browned", "livery", "popcorny" or "cheesy". Thus, the sample was slightly downgraded on freshnessd Overall, these samples were similar in flavor characteristics and intensity to the 8 to 15 da samples.

Comparison of VP Samples

Curves in Figs. 7, 8, 9, and 10 are best fit lines and do not necessarily represent actual data points.

Generally, VP samples remained beefy, fresh, and slightly sour throughout

Figure 7 - Vacuum packaged vs. polyvinyl chloride packaged ground beef: changes in beefy aromatic during display

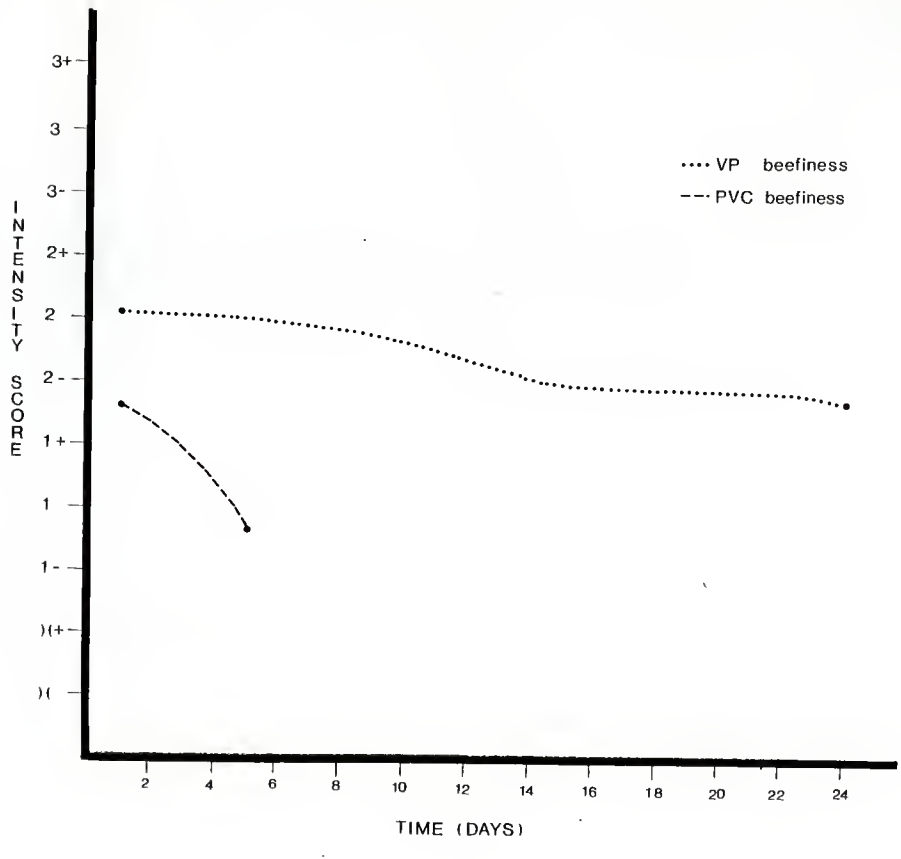

3+
3
3-
2+
2
2-
1+
1
1-
)(+
)(
INTENSITY SCORE
VP beefiness
PVC beefiness
2
4
6
8
10
12
14
16
18
20
22
24
TIME (DAYS)

Figure 8 - Vacuum packaged vs. polyvinyl chloride packaged ground beef: changes in fresh and stale aromatics during display

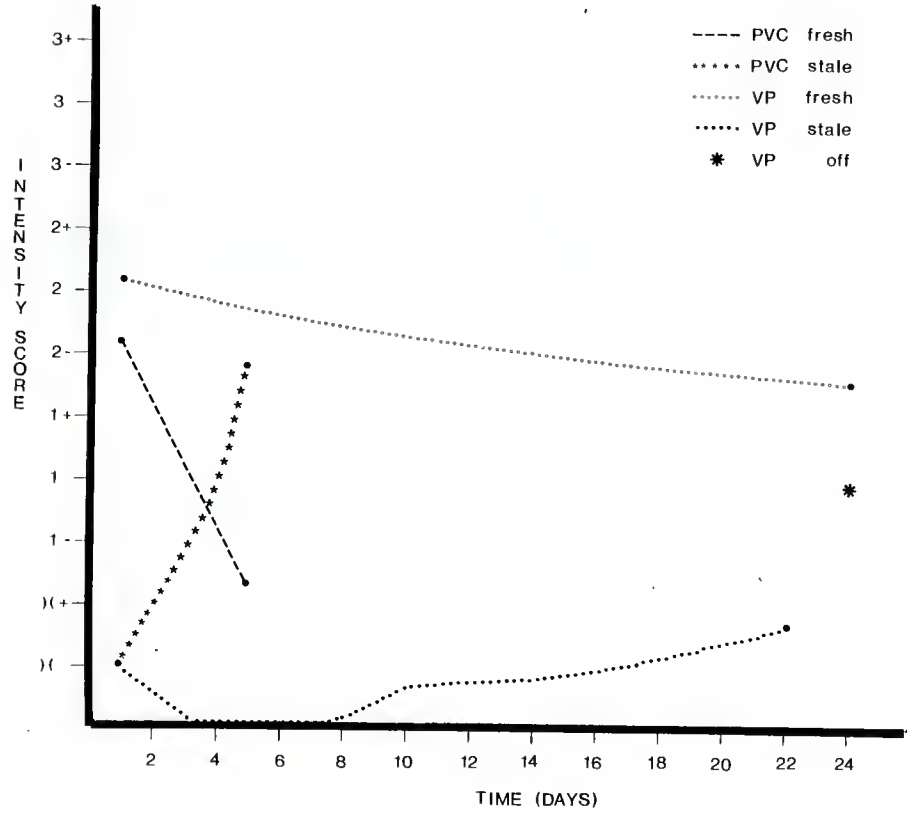

PVC fresh
PVC stale
VP fresh
VP stale
VP off
INTENSITY SCORE
3+
3
3
2+
2
2
1+
1
1
)(+
)(
2
4
6
8
10
12
14
16
18
20
22
24
TIME (DAYS)

Figure 9 - Vacuum packaged vs. polyvinyl chloride packaged ground beef: changes in sour taste during display

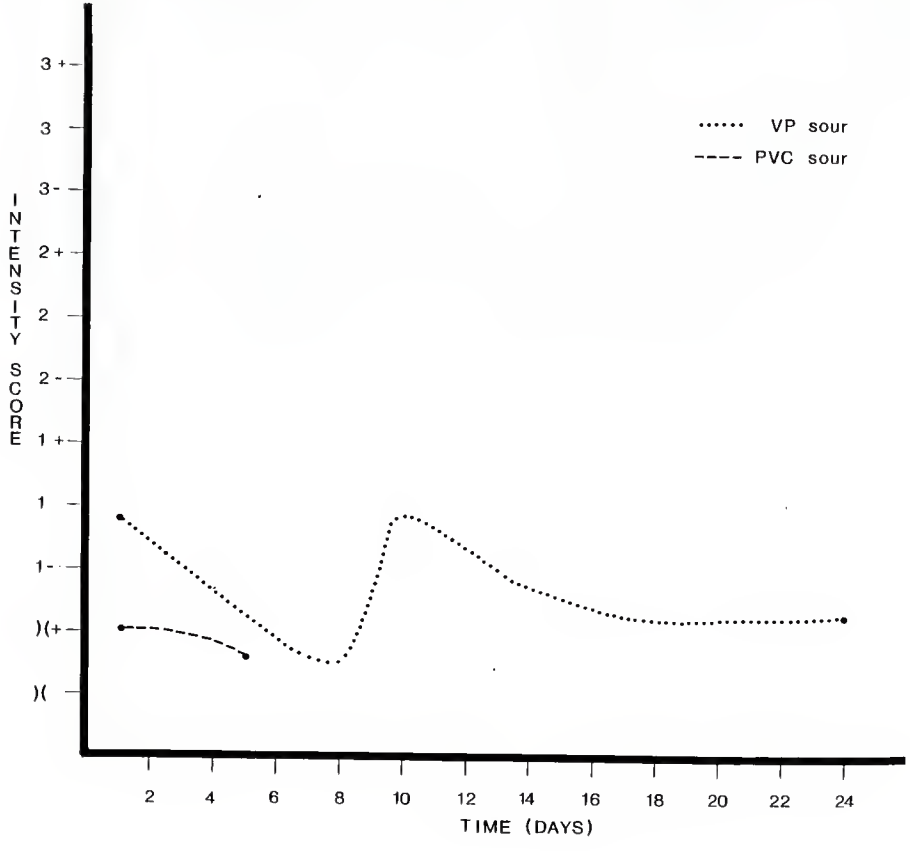
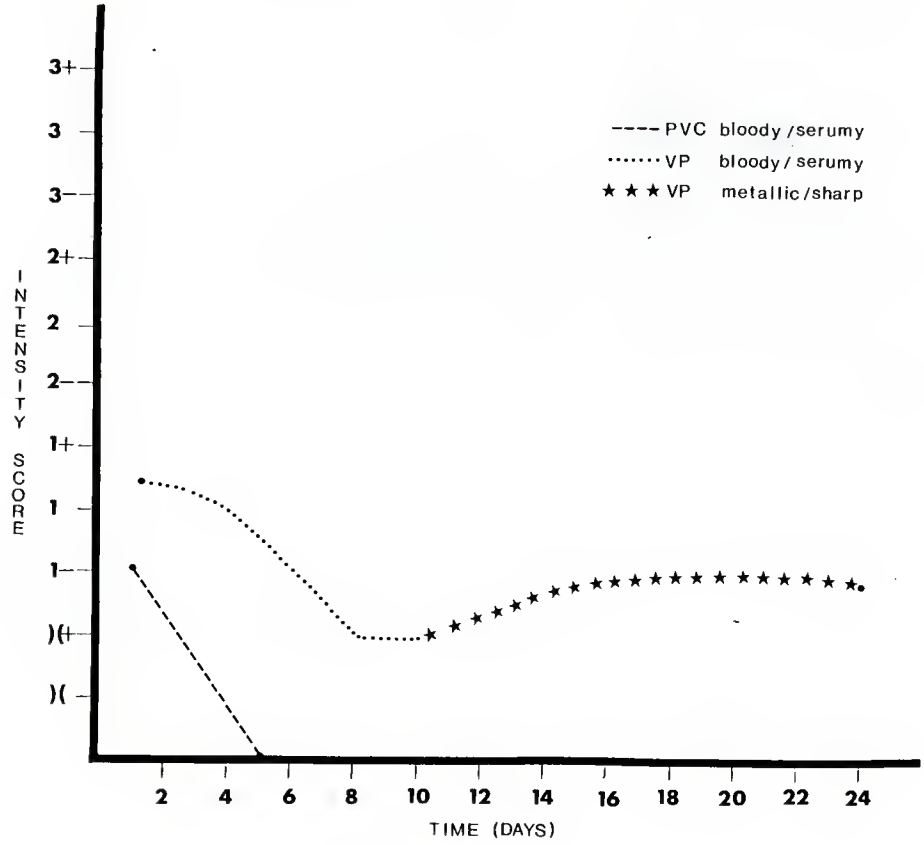

VP sour
PVC sour
INTENSITY SCORE
3+
3
3-
2+
2
2-
1+
1
1-
)(+
)(
2
4
6
8
10
12
14
16
18
20
22
24
TIME (DAYS)

Figure 10 - Vacuum packaged vs. polyvinyl chloride packaged ground beef: changes in bloody/serumy/metallic/sharp aromatics during display.


3+
3
3–
2+
2
2–
1+
1
1–
)(+
)(
INTENSITY SCORE
PVC bloody /serumy
VP bloody / serumy
VP metallic /sharp
2
4
6
8
10
12
14
16
18
20
22
24
TIME (DAYS)

the 24 da display period (Figs. 7, 8, 9). Beefiness and freshness declined only slightly throughout display. A threshold stale was noticed at 10 da (Fig. 6), possibly due to a small increase in the number of pseudomonads. Seideman et al. (1976) reported an increase in fluorescent pseudomonads between 0 and 28 da of vacuum storage. Initial sourness decreased to 8 da, increased to 10 da display, then generally dropped and remained constant. This sourness lingered into the aftertaste after 10 da display and was paired with astringent and metallic aftertastes (Fig. 6). Beefy aftertaste dropped slightly after 3 da display until 8 da at which time it continued to decline, but only very slightly. The bloody/serumy note (Fig. 10) associated with freshly ground beef decreased steadily until 10 da display. At this point, the bloody/serumy note changed to metallic/sharp. Metallic/sharp persisted at a very low level throughout the remainder of the display period.

Pierson et al. (1970) and Jaye et al (1962) attribute the slightly sour flavor of VP beef to the slow development of lactic acid bacteria. Pierson et al. (1970) noted a slight sour flavor after 10-15 da storage. Jaye et al. (1962) reported these sour flavors after 8-10 da of display. Johnson (1974) reported a cheesy flavor in addition to the sour flavor. He concluded that the cheesy and sour flavors were a result of microbial activity. Although our research indicates increasing development of sourness during storage, the sour taste appeared to peak around 10 da. It then tended to decline slightly and remain constant for the remainder of the 24 da display period. These results are somewhat consistent with the findings of Egan and Shay (1982). They reported a slight increase in "off flavor" to 17 da storage, then a slight decrease to 24 da. This "off flavor" could have been a sour note, although the "off flavor" was not

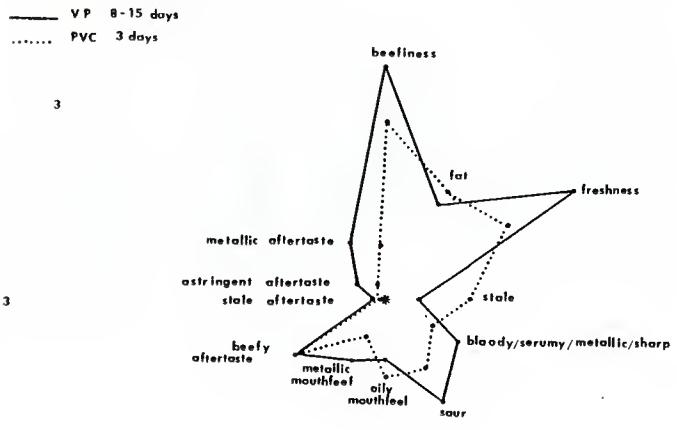
characterized. Griffin et al. (1982) found differences in flavor desirability depending on length of vacuum packaged subprimal storage (0, 12, 24 da) before steak fabrication and display at 2*o.C. Steaks packaged in high oxygen barrier film had flavor ratings that differed from the control after 15, 15, and 20 days for 0, 12, and 24 days of subprimal storage before fabrication, respectively.

Several times during panel session a single member of the panel noted a "livery" flavor in one of the three bites (recorded as 'other' on the ballot). This could have resulted from Lactobacillus, Leuconostoc, or Brochothrix thermosphacta in that particular section of the patty. Egan and Grau (1981) reported rapid development of "off" flavors when vacuum packaged samples were inoculated with Brochothrix thermosphacta. They did not describe the flavor of the 'off flavors'. Egan and Shay (1982), reported Lactobacillus inoculated samples different in flavor from a control after 24 da display. Samples inoculated with Bacillus and Leuconostoc developed off flavors and became significantly different from the control after 35 da. The 'off flavor' was characterized as "sour", "acid", "bitter", and "liver-like" by a trained panel. These flavors may also be associated with Aeromonas hydrophila, Enterobacter liquefaciens, Hafnia alvei, Pseudomonas spp. and Alteromonas putrefaciens although their effect on meat flavor is not clear (Vanderzant et al., 1982).

Comparison of VP and PVC Samples (Fig. 11)

Pseudomonads are thought to be responsible for the putrefaction and stale flavor development in aerobically packaged beef (Johnson, 1974; Baltzer, 1969). The absence or very low levels of these bacteria in VP samples may have

Figure 11 - Flavor profile thumbprint of 8-15 da vacuum packaged vs. 3 da polyvinyl chloride packaged ground beef mean scores


VP 8-15 days
PVC 3 days
beefiness
fat
freshness
metallic aftertaste
astringent aftertaste
stale aftertaste
stale
beefy aftertaste
metallic mouthfeel
oily mouthfeel
bloody/serumy/metallic/sharp
sour

resulted in a beefier, fresher product throughout display. After 3 da display, PVC sample scores were slightly less beefy, less fresh, more stale, slightly less bloody/serumy, slightly less sour, having less of a metallic mouthfeel than mean scores for 8 to 15 da VP samples (Fig. 11). Three da PVC samples had no metallic or astringent aftertaste as did 8 to 15 da VP samples (Fig. 11). Generally, fat, sweet, salty tastes; oily and astringent mouthfeels; and oily, beefy, and stale aftertastes were similar in 3 da PVC and 8 to 15 da VP samples (not pictured in Fig. 11). Degree of vacuum, partial pressure of O_2, residual air in the package, and presence of facultative aerobes or anaerobes may affect the extent of aerobic growth in VP meat and, thus, affect flavor (Hodges et al., 1974). In our research, packaging differences and display length appeared to have the largest effect on flavor differences.

Summary

VP samples were found to have a more constant flavor profile throughout the entire 24 da display period than PVC samples displayed to 5 da. The initial beefy, fresh impact of VP samples after 1 and 3 da display tended to decline slightly during storage. Sourness decreased to 8 da, increased to 10 da and declined slightly thereafter. As time progressed, the beefy note of VP became briefer and was replaced by a sourness which lingered into the aftertaste. Bloody/serumy notes, present in 1 and 3 da VP samples were described as metallic/sharp at 8 da and thereafter.

In contrast, PVC samples declined sharply in beefiness and freshness between 1 and 5 da. Immediately after grinding, samples were beefy, fresh and

bloody/serumy. After 1 da, these notes declined and the sample had a lower flavor impact. After 3 da, beefy, fresh, bloody/serumy notes declined further and a threshold amount of stale was detected. Three da samples were also bland. At 5 da display beef identity was very low as was freshness. Bloody/serumy was not detected. Blandness was replaced by a stale note which lingered into the aftertaste.

The descriptors which most effectively explained flavor differences between 3 da PVC and 8 to 15 da VP samples were: beefiness, freshness, stale/off, bloody/serumy, metallic/sharp, and sour tastes, and metallic mouthfeel and aftertaste. In addition to all the above descriptors, fat flavor, oily and astringent mouthfeel, and oily and stale aftertaste helped describe the changes in the PVC products between 1 and 5 da display.

Based on these results, the generally consistant flavor profile of the VP ground beef should make it a desirable product from the flavor standpoint throughout its display life.

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Chapter VI

APPENDIX

APPENDIX I

Preliminary Study: Color Influences on Consumer Acceptability of Vacuum Packaged Ground Beef, April, 1984

PURPOSE OF STUDY

Americans consume 20.5 billion pounds of beef per year. Forty percent of annual per capita beef consumption is ground (Brown, 1978). It is repeatedly purchased and prepared by 90% of U.S. households (National Live Stock and Meat Board, 1982). Ground beef is an inexpensive beef product, it can be prepared in numerous ways, and its flavor is liked by many market segments (Mize 1972). Current retail packaging systems produce a ground beef retail display life of 2-5 da and a high price discounting frequency because of discoloration or spoilage (Hunt 1984). These problems result from oxygen incorporation and microbial contamination during processing.

Merchandising ground beef in vacuum packaging rather than the current polyvinyl chloride packaging can improve product acceptability and consumer freshness and quality perception, extend display life, reduce product loss, and lower distribution costs. Consumer reaction to vacuum packaged meats' purple color and pre-purchase consumer education have not been thoroughly researched.

This study measures consumer acceptability of vacuum packaged ground beef to determine if the product's purple color decreases purchase intent and if providing the consumer with product information increases purchase intent.

PREVIOUS RESEARCH

COLOR

An appearance factor that affects meat purchases is color (Kropf 1980). Every day consumers judge product color (Judd and Wyszecki 1963). Birren (1963) found that humans react to color. Bright, warm colors of some foods affect the digestive system, stimulating the autonomic nervous system. Soft, cool colors act the opposite. Food product acceptability is judged using color.

A product's color has a real and psychological consumer effect (Hiner 1954). Pangborn (1967), noted "to a large extent, man recognizes, discriminates and selects nutrients with the eye. Through conditioning and association he expects an item of a certain shape and color to have a specific odor, taste and texture." Food product studies support this (Dunker 1939; Hall 1958; Kanig 1955; Moir 1936).

Color greatly affects perceived product quality. For example, consumers associated lighter colored beer with a lighter taste and darker colored beer with a more bitter liquor taste. A general association was made between beer color and consumer preference (Anonymous 1982). Butter is tinted for color control. If it is too white it may resemble lard; if too yellow it may appear rancid in the consumers' eyes (Birren 1982).

The consumer has learned to accept some food color differences. Since consumers have learned to accept the different color that results from the processing of frozen and canned peas (Ernst 1980), perhaps they can learn to accept purple-colored ground beef.

Meat traders accept vacuum packaged beef retail cuts because they understand that the purple color associated with vacuum packaged beef is not a poor quality indicator. According to Taylor (1982), correlation between meat color and eating quality is low. Consumers, used to seeing bright red meat, associate the red color with good quality (Reynolds 1983; Smith 1981; Taylor 1982; Tuma et al 1973). This idea has dominated fresh meat marketing and has hindered the introduction of alternate packaging forms. Some have distinct advantages over traditional approaches.

"The importance of meat color was demonstrated by Naumann et al (1957), who found that consumers consider two different preferences in their meat purchasing. One is a minimum visual appearance if the meat cut is to be bought while the other is palatability, which is determined by the overall quality of the meat. Certainly consumers have few if any means of estimating the flavor, juiciness and tenderness of a cut of meat while it is in the showcase so they must base their selection on visual appearance. Color, of course, is much of what the consumer bases his choice on." (Kropf 1980).

Parents teach children to choose the bright red product when selecting grocery store beef (Smith 1981). The typical consumer chooses packages with a desirable color (Ernst 1980). This discrimination is unfounded, yet consumers are still suspicious of any color abnormality in muscle (Romans and Ziegler 1977). According to Kemp (1980), color greatly affects salability and appearance, even though it affects eating quality little.

Meat color was the most important factor to homemakers when selecting beef (Koudele et al. 1983). Other ranked selection factors evaluated, in order of importance were: amount of fat, price, grade or quality, amount of bone,

marbling, package appearance, number of package servings, and label with preparation suggestions. Stevens (1956) and Mize (1972) concurred that color is important to the consumer when purchasing beef. Other factors are also important. Woods and Jenkins (1963) found price; amount, color and texture of lean; and USDA grade almost equally important.

DEMOGRAPHICS

Woods and Jenkins (1963) asked consumers to list those factors that most influenced their beef purchases. They found educational level was important. Elementary or graduate school educated females considered cost more important than other factors. High school and college graduates felt general product appearance was more important. General cut appearance concerned unskilled employees most, whereas cost was most important to women not working outside the home. Lund et al (1968) found low income households more responsive to price changes, advertising and in-store promotion of meat than higher income or aged, extremely low income persons.

Buchenau (1984) and another meat department manager in the Manhattan area believe consumers will require much product information before accepting purple-red colored beef. Buchneau postulates rural consumers, especially those who are older, will accept the product more slowly. He states that higher income customers with higher levels of education and subsequent open-mindedness are more likely to accept the purple-red color. The other manager disagrees. He believes lower income customers are more likely to accept the vacuum packaged beef. Higher income customers are willing to pay a higher price to get the good quality they associate with bright red beef. He

associates purchase intent with the wealth factor rather than education implications.

CONSUMER EDUCATION

Few studies have focused on vacuum packaged ground beef acceptability. Small scale testing has been done in Minnesota (Ernst 1980; O'Neill 1981). Consumers did notice a meat color difference between polyvinyl chloride packaging (PVC) and vacuum packaging (VP), but did not react adversely. However, PVC and VP beef cuts were not displayed side by side. Results of a study conducted in Sweden where particular attention was paid to consumer education were favorable (Taylor 1982).

Consumer education will determine vacuum packed retail cut success (Ernst 1980; Kropf 1980; Smith 1981; Taylor 1982). Smith (1981) and others believe vacuum packaging of retail cuts has great potential. The problem is getting consumers accustomed to buying purple-colored beef. A large consumer education program is the only tactic to overcome the education problem (Ernst 1980; Taylor 1982). Erdman, the pioneer in vacuum packaging of retail beef cuts, agrees (O'Neill 1981). He says, "Consumer acceptance, however is another matter. You need constant education to get customers to try the beef. Customers come. Customers go. And I'm not sure at all that our initial efforts were on target. There was too much emphasis on the packaging and its clarity. The color of the meat was virtually ignored. Last January we 're-introduced' the package as Fresh-Seal rather than Clear-Cut and we're facing the color problem up front." The Fresh-Seal copy says meat is fresher because the

package seals out air. "And air is what causes beef to lose its freshness. So it's a fact that our vacuum-sealed chucks, etc., will be fresher than the same beef cut and conventionally packaged at the same time. You'll see the difference in our naturally fresher, deeper red color." (O'Neill 1981).

HYPOTHESES

H1: The purple-red color of vacuum packaged beef will adversely affect consumer purchase intent.

H2: Educational materials informing the consumer about vacuum packaged beef will increase purchase intent.

H3: Consumer demographics and buying behavior patterns will not influence purchase intent for vacuum packaged ground beef.

H4: Lean beef color will be the most important factor influencing purchase intent.

H5: Uninformed and informed consumers will find the same differences in the displayed products.

H6: Consumers who perceive vacuum packaged ground beef equal in freshness, and/or quality and/or value to PVC packaged beef will indicate a higher purchase intent for the purple-red product.

METHODS

SAMPLING DESIGN

Questionnaries were distributed to 288 Manhattan, Kansas, grocery store shoppers (Figure 1). Consumers at Dillons (Westloop Shopping Center), Food 4 Less, and Safeway (222 North 6th Street), were study participants. The typical case was a low income, unemployed (outside the home), married female, between 20 and 29 years old and had some college education. Refusal rate was 10%. Sampling was conducted on two consecutive Saturdays, between 9:00am and 5:00pm. The researchers were in pairs. Each pair was randomly assigned to a grocery store.

Grocery store selection was based on location and clientele. Food 4 Less, located on the east side of town, is a warehouse type, discount supermarket. Safeway, in the downtown area, is a neighborhood supermarket. Dillons, in the western section, is a full service supermarket.

Every third adult approaching the meat counter was asked to participate in the study. The approach was: "Hello, my name is ----------. I am a student at Kansas State University. We are doing a consumer study on ground beef and would like you to participate. We have some products for you to look at and a questionnaire for you to fill out. It will take about 10 min. We would really appreciate it if you could take a few min and help us out."

Participating consumers were asked two contingency questions. This allowed questioning of beef purchasers and consumers from households consuming beef at least once a wk. Educational materials regarding purple-red

Figure 1 - CONSUMER GROUND BEEF STUDY PRODUCT EVALUATION QUESTIONNAIRE

This study is being conducted as part of a student research project for a class in the Marketing Department at Kansas State University. All responses will be kept confidential. There are no right or wrong answers. We are interested in your opinions and answers. Your honest answers to the following questions are appreciated. Thank you for your cooperation.

In this section we want to ask you about your beef purchases. Please circle your answer to each question.

Please look at the three samples labeled A, B, and C and answer the following questions.

1. How likely would you be to purchase product A?

   a) very definitely would purchase
   b) definitely would purchase
   c) probably would purchase
   d) may or may not purchase
   e) probably would not purchase
   f) definitely would not purchase
   g) very definitely would not purchase

2. How likely would you be to purchase product B?

   a) very definitely would purchase
   b) definitely would purchase
   c) probably would purchase
   d) may or may not purchase
   e) probably would not purchase
   f) definitely would not purchase
   g) very definitely would not purchase

3. How likely would you be to purchase product C?

   a) very definitely would purchase
   b) definitely would purchase
   c) probably would purchase
   d) may or may not purchase
   e) probably would not purchase
   f) definitely would not purchase
   g) very definitely would not purchase

4. What is the major difference between products A, B, and C? (Please be brief.)

_____

5. I think the packaging of products A, B, and C is similar.

a) very strongly agree
b) strongly agree
c) slightly agree
d) no opinion
e) slightly disagree
f) strongly disagree
g) very strongly disagree

6. Color influenced my purchase decision when evaluating products A, B, and C.

a) very strongly agree
b) strongly agree
c) slightly agree
d) no opinion
e) slightly disagree
f) strongly disagree
g) very strongly disagree

Now please look at the samples labelled D, E, and F and answer the following questions.

7. How likely would you be to purchase product D?

a) very definitely would purchase
b) definitely would purchase
c) probably would purchase
d) no opinion
e) probably would not purchase
f) definitely would not purchase
g) very definitely would not purchase

8. How likely would you be to purchase product E?

a) very definitely would purchase
b) definitely would purchase
c) probably would purchase
d) no opinion
e) probably would not purchase
f) definitely would not purchase
g) very definitely would not purchase

9. How likely would you be to purchase product F?

a) very definitely would purchase
b) definitely would purchase
c) probably would purchase
d) no opinion
e) probably would not purchase
f) definitely would not purchase
g) very definitely would not purchase

10. What was the major difference between products D, E and F? Please be brief.

---

11. I think the packaging of products D, E, and F is similar.

a) very strongly agree
b) strongly agree
c) slightly agree
d) no opinion
e) slightly disagree
f) strongly disagree
g) very strongly disagree

12. Price influenced my purchase decision when evaluating products D, E, and F.

a) very strongly agree
b) strongly agree
c) slightly agree
d) no opinion
e) slightly disagree
f) strongly disagree
g) very strongly disagree

13. Color influenced my purchase decision when evaluating products D, E and F.

a) very strongly agree
b) strongly agree
c) slightly agree
d) no opinion
e) slightly disagree
f) strongly disagree
g) very strongly disagree

14. How often do you shop in this particular store?

a) more than once a week
b) once a week
c) once every two weeks
d) once a month
e) rarely

15. Grocery ads influence my choice of grocery stores.

a) very strongly agree
b) strongly agree
c) slightly agree
d) no opinion
e) slightly disagree
f) strongly disagree
g) very strongly disagree

16. Where do you make the majority of your beef purchases?

a) Dillons
b) Dutch Maid
c) Food 4 Less
d) Aldi Foods
e) Safeway
f) Manhattan Wholesale Meat Market
g) Privately owned slaughter plants
h) Other, please list _____

17. In your opinion which grocery store chain in Manhattan offers the highest quality beef?

a) Dillons
b) Dutch Maid
c) Food 4 Less
d) Aldi Foods
e) Safeway
f) Other, please list _____

18. How often do you purchase beef?

a) more than once a week
b) once a week
c) once every two weeks
d) once a month
e) rarely

19. When making beef purchases, what quantity do you typically buy?

a) less than 5lbs.
b) more than 5lbs. but less than 10lbs.
c) more than 10lbs. but less than 20lbs.
d) 20lbs. or more

20. Beef prices influence my beef purchase decision.

a) very strongly agree
b) strongly agree
c) slightly agree
d) no opinion
e) slightly disagree
f) strongly disagree
g) very strongly disagree

21. The fat content of ground beef influences my beef purchase decision.

a) very strongly agree
b) strongly agree
c) slightly agree
d) no opinion
e) slightly disagree
f) strongly disagree
g) very strongly disagree

22. Of the following items, which one is most important to you when selecting ground beef.

a) package appearance
b) amount of fat
c) total price of package
d) price per pound
e) number of servings from each package
f) color of beef
g) store where beef is sold

23. How much do you typically spend when making a single beef purchase?

a) $0-$5.00
b) $5.01-$10.00
c) $10.01-$20.00
d) $20.01-$40.00
e) $40.01-$60.00
f) $60.01 and over

24. The packaging of beef products influences my purchase decision.

a) very strongly agree
b) strongly agree
c) slightly agree
d) no opinion
e) slightly disagree
f) strongly disagree
g) very strongly disagree

25. I would be as willing to purchase purple ground beef as I would be to purchase red ground beef.

a) very strongly agree
b) strongly agree
c) slightly agree
d) no opinion
e) slightly disagree
f) strongly disagree
g) very strongly disagree

26. I think purple ground beef is as fresh as red ground beef.

a) very strongly agree
b) strongly agree
c) slightly agree
d) no opinion
e) slightly disagree
f) strongly disagree
g) very strongly disagree

27. I think purple ground beef has the same high quality as red ground beef.

a) very strongly agree
b) strongly agree
c) slightly agree
d) no opinion
e) slightly disagree
f) strongly disagree
g) very strongly disagree

28. I would be willing to pay the same price for purple ground beef as for red ground beef.

a) very strongly agree
b) strongly agree
c) slightly agree
d) no opinion
e) slightly disagree
f) strongly disagree
g) very strongly disagree

DEMOGRAPHIC INFORMATION

In this section, we want to ask you about some background characteristics. We are interested in seeing how different types of people answered the questions throughout the study.

1. What is your age?

a) under 18
b) 18-24
c) 25-34
d) 35-44
e) 45-54
f) 55-64
g) 65 and over

2. Your sex is?

a) male
b) female

3. What is the last education level you completed?

a) grade school
b) middle school
c) high school
d) vo-tech
e) some college
f) bachelor's degree
g) master's degree
h) doctorate degree

4. What is your occupation? Please list.

_____

5. What is your total household 1983 pre-tax income level?

a) under $5,000
b) $5,000-$9,999
c) $10,000-$14,999
d) $15,000-$19,999
e) $20,000-$24,999
f) $25,000-$29,999
g) $30,000-$39,999
h) $40,000-$49,999
i) $50,000 and over

6. What is your marital status?

a) single
b) married
c) widowed
d) separated
e) divorced

7. What stage of the life cycle do you consider yourself to be in?

a) young, single
b) young married, no children
c) young married, with youngest child under six
d) married, with youngest child over six
e) older, married, no children
f) older, single

8. What is your religion?

a) catholic
b) protestant
c) mormon
d) jewish
e) none
f) other, please list _____

9. What is the approximate size of your hometown?

a) 0-2,500
b) 2,501-10,000
c) 10,001-20,000
d) 20,001-50,000
e) 50,001-100,000
f) 100,001-500,000
g) Over 500,000

10. What is your hometown? Please list

_____

Figure 2 - Consumer Educational Information

When ground beef is exposed to air it will lose its fresh color. The new vacuum-seal wrapping used for packaging red meat products, keeps air away from freshly cut beef. The wrapping used for conventionally packaged beef does not keep air away. Thus, vacuum-sealed beef will be fresher than the same beef conventionally packaged.

You can see the freshness for yourself!

Purple is the natural color of fresh beef before it has been exposed to air. Once beef is exposed to air, it turns a bright cherry-red color. Most people associate this cherry-red meat color with freshness. Actually, meat changes color when exposed to air. When first cut, beef is purple. As time progresses, it turns red. Finally, after a few days it turns brown. So, when beef is purple (with vacuum-sealing), it is freshest.

colored vacuum packaged beef were presented to 50% of the study participants (Figure 2). Participants with odd numbered questionnaires received educational materials. Even numbered questionnaire recipients were uninformed.

SAMPLE PREPARATION

Beef trim (steers) was obtained from the Kansas State University Meats Laboratory facility. Samples were vacuum packaged (Smith Super Vac) and stored at 1.1°C until they were ground. Samples were coarse ground through a 1.27cm plate then fine ground through a .32cm plate (Hobart). Fat content was standardized at 25% using the Hobart Fat Analysis apparatus. After fat content standardization, 14kg samples were packaged immediately. Styrofoam trays, size 8, were used.

Beef samples for the brown, metmyoglobin color were ground and packaged 8 da preceding the test. Samples were wrapped with PVC film and heat sealed. Packages were stored at 1.1°C for 6 da, at room temperature (21°C) for 12 hr and at 1.1°C for the remaining 36 hr. Samples displaying the purple, reduced myoglobin color were ground and packaged 48-72 hr prior to the survey. They were placed in oxygen impermeable barrier bags (Cryovac), vacuum-sealed (Smith Super Vac), and stored at 1.1°C until testing time. Red, oxymyoglobin samples were ground and packaged 36 hr prior to the survey. Packages were wrapped with PVC film, heat sealed, and stored at 1.1°C.

Immediately preceeding each survey date, Hunter Color Lab (L, a, b) readings were taken. One randomly selected package of each pigment was

measured. Readings were taken at three locations on each sample. T-test results indicate samples of the same pigment had the same ($P>.05$) L value. Values for a, and a and b differed ($P<.05$) for red and purple respectively.

During testing, samples were displayed through standardized rectangles cut in white butcher paper. This minimized packaging appearance differences. Open refrigerator cases displayed samples at approximately $0^{\circ}C$.

VARIABLES

The dependent variable is consumer purchase intent for vacuum packaged ground beef. Twenty-one independent variables were measured. They were: beef color, product knowledge, store image, frequency of shopping in a particular store, frequency of beef purchases, quantity of beef purchases, product price, age, sex, educational background, occupation, household income, grocery advertising, store offering highest quality beef, fat content of beef, marital status, religion, quality perception of purple beef versus red and brown, freshness of purple beef versus red and brown, consumer willingness to purchase purple beef, and consumer willingness to pay the same price for purple versus red beef.

The effect of consumer information regarding purple-colored vacuum packaged ground beef on purchase intent was tested (questions 1-4, 25-28). Questions 1-3 showed red, purple and brown colored ground beef to the consumers and asked how willing they would be to purchase each of the three products presented. Questions 25-28 asked consumers their perception of the equality of red and purple beef characteristics. A seven category Likert scale

was used (1=very definitely would purchase, 7=very definitely would not purchase for Questions 1-3; 1=very strongly agree, 7=very strongly disagree for Questions 25-28). Question 4 was an open-ended question regarding consumer perceptions of the main difference between the three products. Responses were coded as follows: 1=color, 2=fat, 3=fat and color, 4=freshness, 5=fat and freshness, and 6=other.

Buyer behavior was evaluated to determine how it influenced purchase intent (questions 14-24). Interval scaled questions measured these independent variables. Interval scaled responses used a seven category Likert scale (1=very strongly agree, 7=very strongly disagree).

Age, sex, educational background, occupation, total household income, marital status, lifecycle stage, religion and hometown size were scaled and evaluated for impact on purchase intent. Open ended responses to the occupation question were recoded to the following: 1=not employed, 2=student, 3=educator, 4=laborer, 5=professional, 6=administrative, 7=service, 8=clerical/sales, and 9=other.

Results show that 82.3% of all ground beef purchases are between 1 and 10 lb. The Beef Industry Council of the National Livestock and Meat Board (1982) found that a large majority of ground beef purchases were small. Seventy percent of those surveyed were between 20 and 49 years old. The Beef Industry Council of the National Livestock and Meat Board (1982) found that 80% of beef purchasers were between 25 and 44 years old. This study found a large number of consumers, 50%, purchased ground beef one or more times a week. This finding is consistent with research which showed that 50% of households shop once a week or more (Koudele 1983). This study entailed a representative

sampling of typical beef purchasers.

DATA ANALYSIS

Data were analyzed with SPSS. Frequencies and bivariate percentages indicated variable relationships. Pearson correlation coefficients and stepwise regression were used to complete the statistical analyses.

RESULTS

Data show no differences ($P>.05$) in demographic or buying behavior characteristics between informed and uninformed consumers. The hypothesis that vacuum packaged beef's purple color will adversely affect consumer purchase intent was supported. Mean purchase intent scores for red, purple and brown samples were 2.5, 3.8, and 5.6 respectively. (1=very definitely would purchase, 4=may or may not purchase, 7=very definitely would not purchase)

The chi-square analysis in Table 1 shows that educational materials informing the consumer about vacuum packaged beef increased purchase intent ($P<.05$). Approximately 56% of the informed consumers indicated a willingness to purchase purple colored ground beef compared to 31% of the uninformed consumers. Eighteen percent of the informed consumers would not purchase purple ground beef while 47% of the uninformed consumers indicated nonpurchase intent. Eta values indicate a weak relationship.

Consumer demographics and buying behavior patterns did not influence

TABLE 1

BIVARIATE PERCENTAGE TABLE OF WILLINGNESS TO PURCHASE PURPLE GROUND BEEF BY INFORMED AND UNINFORMED CONDITIONS

Response Category	Informed	Uninformed
Very definitely would purchase/ Definitely would purchase/ Probably would purchase	55.9	30.6
May or may not purchase	25.9	22.9
Probably would not purchase/ Definitely would not purchase/ Very definitely would not purchase	18.2	46.5
	N=144	N=140

p<.001
Eta=0.31139

(P>.05) purple colored ground beef purchase intent. Table 2 shows significant chi-square values (P<.05) for "pricing influences purchases" and "packaging influences purchases". Low gamma values for these variables indicated a weak relationship. They did not appear in regression equations.

Results did not support the hypothesis that lean beef color will be the most important factor influencing purchase intent. Consumers indicated fat was the most important factor when making purchase decisions (42%). Color (23%) and price per pound (16%) followed. Fat influence on purchasing behavior did not differ for informed and uninformed consumers (chi-square P>.05). Fat influenced purchase intent the same amount for each meat color.

Uninformed and informed consumers found the same differences in the observed products. There were no significant chi-square values (P>.05) for any of these comparisons. Both groups found the major difference between the packages was color (64%). Fat, freshness, or combinations of the above followed. Both informed and uninformed agreed that all packaging was similar. Price influenced their purchase decisions similarly.

Data from Table 3 support the hypothesis that consumers who perceived vacuum packaged ground beef equal in freshness, and/or quality, and/or price to PVC packaged ground beef would indicate a higher purchase intent for the purple product. Informed and uninformed consumers' perceived equality of red and purple colored ground beef showed differences based on chi-square (P<.000). Percentages indicate that informed consumers were as willing to purchase purple ground beef as red ground beef. They largely agreed that purple ground beef is as fresh as red ground beef, that purple ground beef has the same high quality as red ground beef and that they would be as willing to pay the same

TABLE 2

PERCENTAGE TABLE OF PURCHASE INTENT OF PURPLE GROUND BEEF BY DEMOGRAPHIC AND BUYER BEHAVIOR CHARACTERISTICS

Characteristic	VD-DWP	PWP	MMNP	PWNP	D-VDWNP	MOA
How often shop at location						
more than once a week	16.1	19.4	21.0	28.2	19.4	Eta=
once a week	16.2	28.6	26.7	21.9	6.7	0.115
once avery two weeks	16.9	26.2	23.1	26.2	7.7	
less than once every two wks	23.1	26.9	23.1	15.4	11.5	N=284
Grocery ads influcence purchase						
very strongly agree	21.4	32.1	25.0	17.9	3.6	Gamma=
strongly/slightly agree	20.0	28.3	23.3	16.7	11.7	0.133
no opinion	16.3	23.6	24.8	24.8	8.5	
slight-very strong disagree	16.4	20.9	22.4	23.9	16.4	N=284
Where majority of purchases made						
Dillons	18.9	23.3	26.7	17.8	13.3	Eta=
Food 4 Less	16.9	27.1	25.4	27.1	3.4	0.052
Safeway	14.7	27.9	20.6	23.5	13.2	
Other	19.4	25.4	22.4	22.4	10.4	N=284
Which chain highest quality						
Dillons	19.3	23.6	24.3	22.1	10.7	Eta=
Food 4 Less	16.0	16.0	28.0	32.0	8.0	0.048
Safeway	18.2	28.8	18.2	22.7	12.1	
Other	15.6	35.6	22.2	17.8	8.9	N=276
How often purchase beef						
once a week or more	13.9	29.9	24.3	22.2	9.7	Eta=
once every two weeks	23.3	20.5	27.4	17.8	11.0	0.069
once a month	13.8	23.7	21.1	31.6	7.9	
less than once a month	24.0	24.0	16.0	16.0	20.0	N=280
How much purchased						
1-5 pounds	17.4	26.3	24.2	23.7	8.4	Eta=
6-10 pounds	14.9	27.7	23.8	19.1	14.9	0.036
more than 10 pounds	20.9	23.3	23.3	18.6	14.0	N=280
[a]Prices influcence purchase						
very strongly agree	18.8	27.1	29.2	12.5	12.5	Gamma=
strongly agree	23.2	30.3	28.0	11.0	7.3	0.160
slightly agree	12.5	24.0	18.8	34.4	10.4	
slightly-v strongly disagree	16.2	24.3	21.6	18.9	18.9	N=263
Fat influcences purchase						
very strongly agree	14.5	20.9	27.3	23.6	13.6	Gamma=
strongly agree	18.3	29.6	20.0	22.6	9.6	-0.161
slightly agree	14.6	34.1	26.8	17.1	7.3	
slightly-v strongly disagree	40.0	13.3	26.7	——20.0——		N=281
Factor most important						
package appearance/servings	25.0	17.9	28.6	14.3	14.3	Eta=
amount of fat	14.8	22.6	23.3	29.6	9.6	0.115
price of package	12.0	24.0	40.0	12.0	12.0	
price per pound	20.5	34.1	22.7	13.9	6.8	
color of meat	20.3	28.1	17.2	21.9	12.5	N=276

Characteristic	VD-DWP	PWP	MMNP	PWNP	D-VDWNP	MOA
How much spent on purchase						
$0 to $3.00	14.9	26.3	21.1	24.6	13.2	Eta=
$3.01 to $10.00	19.4	23.5	26.5	22.4	8.2	0.089
over $10.00	19.7	28.8	25.8	16.7	9.1	N=278
[b]Packaging influances purchases						
very strongly agree	27.3	27.3	4.5	18.2	22.7	Gamma=
strongly agree	29.8	24.6	14.0	13.8	15.8	0.061
slightly agree	11.9	24.6	31.4	26.3	5.9	
no opinion	17.8	26.7	22.2	22.2	11.1	
slightly-v strongly disagree	12.2	26.8	29.3	22.0	9.8	N=283
Educational level achieved						
vo-tech or less	15.7	29.4	18.6	23.5	12.7	Eta=
some college	15.1	26.3	30.0	21.3	7.6	0.128
college degree or more	21.8	20.8	24.8	21.8	10.9	N=283
Age						
29 and under	13.5	28.0	28.0	22.0	8.5	Eta=
30-49	22.0	23.0	23.0	21.0	9.0	0.062
over 49	18.4	24.6	15.4	24.6	17.0	N=283
Sex						
Male	12.3	27.6	26.5	22.4	11.2	Eta=
Female	20.6	23.9	22.8	22.3	10.3	0.067
						N=282
Occupation						
not employeed	19.3	21.1	26.3	26.3	7.0	Eta=
student	18.4	18.3	30.0	28.3	5.0	0.081
educator	16.7	16.7	30.0	20.0	16.7	
professional	26.4	21.1	5.3	26.3	21.1	
clerical/safas	21.9	28.1	21.9	15.6	12.6	
other	13.6	31.8	22.7	22.7	9.1	N=271
Marital Status						
Single	14.3	32.1	27.4	20.2	6.0	Eta=
Married	18.6	22.4	24.2	24.8	9.9	0.144
Widowed	35.3	23.3	5.9	17.6	17.7	
Divorced	7.1	28.6	21.4	7.1	35.7	N=276
Religion						
Catholic	12.1	25.8	28.8	21.2	12.1	Eta=
Protestant	23.0	23.7	19.7	23.0	10.5	0.127
None	4.3	39.1	21.7	17.4	17.3	
Other	11.8	26.3	32.4	26.5	2.9	N=273
Income						
0-14,999	19.5	29.7	23.4	20.3	5.1	Eta=
13,000-29,999	15.6	21.1	22.2	22.2	18.9	0.144
30,000 & over	16.9	22.0	25.4	23.7	11.9	N=267

[a] p<.05
[b] p<.05

VD-DWP=very definitely/definitely would purchase
PWP=probably would purchase
MMNP=may or may not purchasa
PWNP=probably would not purchase
D-VDWNP=definitely/very definitely would not purchase
MOA=measure of association

TABLE 3

EQUALITY OF RED AND PURPLE GROUND BEEF BY INFORMED TO UNINFORMED CONDITIONS

Response Category	Equal Purchase Intent Red vs. Purple		Willing to Pay Same Price Red vs. Purple		Equality of Freshness Red vs. Purple		Equal Quality Red vs. Purple	
	Inform	Uninform	Inform	Uninform	Inform	Uninform	Inform	Uninfom
V. strongly agree	16.7	3.6	20.1	5.8	16.9	7.2	14.7	6.4
Strongly agree	21.5	13.6	21.5	7.2	23.2	12.9	26.	11.4
Slightly agree	31.3	15.7	25.0	12.3	27.5	12.2	30.8	15.0
No opinion	9.0	5.7	11.8	13.0	.2	17.3	8.4	28.6
Slightly disagree	13.2	18.6	10.4	26.8	16.9	21.6	9.8	19.3
Strongly disagree	4.9	22.9	7.6	16.7	4.9	15.8	7.0	11.4
V. strong. disagree	3.5	20.0	3.5	18.1	1.4	12.9	2.8	7.9
	N=144	N=140	N=144	N=138	N=142	N=139	N=143	N=140
	P<.001 Eta=.0.426		P<.001 Eta=0.431		P<.001 Eta=0.354		P<.001d Eta=0.315	

price for both products. Uninformed consumers largely disagreed with all the above statements.

Table 4 shows a comparison of the dependent variable and the previously mentioned quality variables. The dependent variable showed differences at different levels of the independent variables ($P<.000$). Gamma values indicated a moderately strong relationship.

Pearson correlations in Table 5 indicate the importance of study date, educational materials, the influence of price on purchase intent, the influence of fat on purchase intent, the willlingness to pay the same price for red as purple ground beef, and the perceived equality of red and purple colored ground beef (freshness, quality) as correlated with purple beef purchase intent. The stepwise regression equation in Table 6, included pricing equality, study date, and educational materials. An adjusted R^2 of .2101 indicates that the independent variables weakly explain the dependent variable.

DISCUSSION

Consumers are less likely to purchase purple colored ground beef than red. This is consistent with research showing that consumers associate bright red meat with good quality and that consumers are suspicious of meat color abnormalities. This study showed buyer behavior characteristics and demographics unimportant in explaining purple colored ground beef purchase intent. Previous studies found educational level and occupation influence purchase decisions.

TABLE 4

CHI-SQUARED ANALYSIS ABLE OF PURCHASE INTENT FOR PURPLE GROUND BEEF BY PERCEIVED EQUALITY OF RED AND PURPLE

Buyer Behavior	Gamma
Purchase Red vs. Purple	0.45041
Freshness Red vs. Purple	0.41476
High Quality Red vs. Purple	0.38105
Price Red vs. Purple	0.43954
P<.0001 N=281	

TABLE 5

PEARSON'S CORRELATION OF PURCHASE INTENT OF PURPLE GROUND BEEF WITH THE INDEPENDENT VARIABLES

I.V.	PURB	STORE	DATE	EDUC	PURRP	PRCRP	FRSRP	QALRP
STORE	0.046							
DATE	-.194	0.000						
EDUC	0.331	-.009	0.003					
PURRP	0.378	-.018	-.043	0.381				
PRCRP	0.351	-.062	-.011	0.369	0.696			
FRSRP	0.337	-.051	-.085	0.313	0.720	0.717		
QALRP	0.292	-.021	-.094	0.254	0.556	0.652	0.680	
PRINF	0.114	0.087	-.047	0.101	0.084	-.063	0.023	-.028

N=280

Values in table represent correlation coefficients

I.V.=independent variables
PURB=Willingness to purchase purple ground beef
STORE=Store where survey was conducted
DATE=Date on which survey was conducted
EDUC=Whether or not consumer was informed about vacuum packaged beef
PURRP=Whether or not consumer would be as willing to purchase purple ground beef as red.
PRCRP=Whether or not consumer would be willing to pay the same price for purple as red ground beef
FRSRP=Whether or not the consumer believes purple is as fresh as red ground beef.
QALRP=Whether or not the consumer believes purple has the same high quality as red ground beef.
PRINF=The influence price has on purchase intent.

TABLE 6

STEPWISE REGRESSION OF MAJOR FACTORS AFFECTING WILLINGNESS TO PURCHASE PURPLE-COLORED GROUND BEEF

Variable	Equation 1 b	Equation 1 Beta	Equation 2 b	Equation 2 Beta	Equation 3 b	Equation 3 Beta	Equation 4 b	Equation 4 Beta
EDUC	-0.6621	0.2040	0.7035	0.2296	-0.7784	-0.3201	-0.7737	-0.2455
DATE	-0.4960	-0.1712	-0.6691	-0.2154	-0.4823	-0.1688	-0.4826	-0.1683
PRCDEF	0.1181	0.1129			0.1271	0.1223	0.1308	-0.1253
PURRDPU	0.2741	0.3706						
PRCRDPU			0.2963	0.3553				
FRSHRDPU					-0.4823	0.2448		
QUALRDPU							0.2601	0.3181
Multiple R		0.4630		0.4682		0.4481		0.4481
R^2		0.2143		0.2192		0.1998		0.2008
Adjusted R^2		0.2022		0.2101		0.1874		0.1664

N=289

Researchers believe consumer education necessary for acceptance of vacuum packaged ground beef. Study results support this hypothesis. If consumers perceive purple and red ground beef equal in freshness and quality, purchase intent is increased. Informed consumers are more likely to perceive these characteristics equal.

Fat content was the most important characteristic when selecting beef. Although different from previous findings, these results are understandable. The current 'health and fitness' trend has increased lean ground beef demand.

LIMITATIONS

There were several study limitations. Manhattan's midwest location, small size, and college town characteristics limit generalizations about the beef purchasing public. Convenience sampling and the date effect limit result reliability. Measuring purchase intent does not translate into actual purchase behavior.

There were no differences ($P>.05$) in demographic or buying behavior characteristics between informed and uninformed consumers. This suggests that within the convenience sample the assignment of informed and uninformed samples was random. Insignificant differences in controlled variables, such as fat content, show that color, the treatment, is causing the changes in purchase intent, the dependent variable. Insignificant differences in other external factor responses, such as store choice, perception of store choice, perception of store quality, average amount spent on beef, and frequency of beef purchases suggest internal validity.

MARKETING IMPLICATIONS

Educational materials regarding vacuum packaged beef must be distributed to consumers in order for them to accept vacuum packaging. The materials should stress the equality of red and purple ground beef in terms of freshness, quality, and price. National Live Stock and Meat Board television advertising, women's magazine advertising, point-of-purchase displays, case signs, wall signs, public address (in-store) announcements, product sampling, pamphlets distributed by county extension home economists and school educational programs will accomplish this.

Information should emphasize product benefits. Vacuum packaging is convenient. Packages do not need rewrapping before freezing. Packages are leakproof, unlike PVC packages. Vacuum packaged beef tastes fresher (Lynch, 1984). This information may increase perceived quality and freshness equality.

Separate educational materials are not needed for different population segments. One program can be developed for all target market segments in Manhattan. These segments are 25-44 year olds, blue and white collar workers, and employed women.

Study date influenced purchase intent. This may be because one date was at the end of the month and the other at the beginning. Consumers may be more willing to try a new product at the beginning of the month when they have more disposable income. Educational materials may be more effective at certain times of the month.

Vacuum packaging saves the processor money. It can lower distribution

costs and reduce product loss. All packaging can be centrally located and the VP product shipped to retailers, lowering distribution costs. This is similar to the currently used "boxed beef" concept. Longer shelf life will reduce product loss due to price discounts.

FUTURE RESEARCH

Future studies should use ground beef packages similar to typical PVC packages in size, weight and appearance. Sample display locations should be standardized for all stores in which the study is conducted. A larger sample size should be obtained, expanding to a national basis. Surveys should be conducted more frequently during the month. Studies should investigate actual purchase behavior in addition to purchase intent.

Marketers should further investigate appropriate educational material content. They need to determine those factors which will most increase consumers' vacuum packaged beef purchase intent. They should determine tactics which will convince consumers of vacuum packaged beef's favorable qualities. Different types of media such as newspapers, magazines, and television should be analyzed for effectiveness in educating consumers concerning vacuum packaged ground beef. The different distribution channels should be researched to determine the most effective method.

Once the best way to inform consumers has been determined, small scale test marketing should be conducted. If results are favorable, the possibility of expanding vacuum packaging to include other cuts of meat can be studied.

Price is important when making ground beef purchase decisions. Marketers

should research introductory prices and their effectiveness in generating trial. The National Live Stock and Meat Board (1982) found that when beef prices dropped, 44% of consumers indicated they would buy more beef.

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APPENDIX 2

Informed Consent Statement and Product Evaluation Questionnaire

INFORMED CONSENT STATEMENT

1. I volunteer to participate in a research project entitled Consumer Ground Beef Study. This study is being conducted as part of a research project for the Food Science program in the Department of Animal Science and Industry at Kansas State University. We are studying consumer attitudes towards ground beef purchases.

2. I understand that my performance as an individual will be treated as research data and will in no way be associated with me, thereby assuring confidentiality of my responses.

3. There are no right or wrong answers. We are interested in your opinions and answers. Your honest answers to the following questions are appreciated. Thank you for your cooperation.

I have read and signed the Informed Consent Statement, this ____ day of August, 1984.

Signature_____

PRODUCT EVALUATION QUESTIONNAIRE

In this section we want to ask you about your beef purchases. Please circle your answer to each question. Circle one response for each item.

Please look at the three samples labeled 725, 359 and 648 and answer the following questions. The numbers were chosen at random to identify the products and have no other meaning.

1. How likely would you be to purchase product 725?

   a) very definitely would purchase
   b) definitely would purchase
   c) probably would purchase
   d) may or may not purchase
   e) probably would not purchase
   f) definitely would not purchase
   g) very definitely would not purchase

2. How likely would you be to purchase product 359?

   a) very definitely would not purchase
   b) definitely would not purchase
   c) probably would not purchase
   d) may or may not purchase
   e) probably would purchase
   f) definitely would purchase
   g) very definitely would purchase

3. How likely would you be to purchase product 648?

   a) very definitely would purchase
   b) definitely would purchase
   c) probably would purchase
   d) may or may not purchase
   e) probably would not purchase
   f) definitely would not purchase
   g) very definitely would not purchase

4. What is the major difference between products 725, 359, 648? (Please be brief.)

_____

5. I think the packaging of products 725, 359, and 648 is similar.

   a) very strongly agree
   b) strongly agree
   c) slightly agree
   d) no opinion
   e) slightly disagree
   f) strongly disagree
   g) very strongly disagree

6. I think the fat content of products 725, 359, and 648 is similar.

   a) very strongly disagree
   b) strongly disagree
   c) slightly disagree
   d) no opinion
   e) slightly agree
   f) strongly agree
   g) very strongly agree

7. Fat content influenced my purchase decision when evaluating products 725, 359, and 648.

   a) very strongly agree
   b) strongly agree
   c) slightly agree
   d) no opinion
   e) slightly disagree
   f) strongly disagree
   g) very strongly disagree

8. Color influenced my purchase decision when evaluating products 725, 359, and 648.

   a) very strongly disagree
   b) strongly disagree
   c) slightly disagree
   d) no opinion
   e) slightly agree
   f) strongly agree
   g) very strongly agree

9. How often do you shop in this particular store?

   a) more than once a week
   b) once a week
   c) once every two weeks
   d) once a month
   e) rarely

10. How often do you purchase beef?

a) more than once a week
b) once a week
c) once every two weeks
d) once a month
e) rarely

11. When making beef purchases, what quantity do you typically buy?

a) less than 5lbs.
b) more than 5lbs. but less than 10lbs.
c) more than 10lbs. but less than 20lbs.
d) 20lbs. or more

12. Ground beef prices influence my beef purchase decision.

a) very strongly agree
b) strongly agree
c) slightly agree
d) no opinion
e) slightly disagree
f) strongly disagree
g) very strongly disagree

13. The fat content of ground beef influences my beef purchase decision.

a) very strongly disagree
b) strongly disagree
c) slightly disagree
d) no opinion
e) slightly agree
f) strongly agree
g) very strongly agree

14. Of the following items, which <u>one</u> is most important to you when selecting ground beef.

a) package appearance
b) amount of fat
c) total price of package
d) price per pound
e) color of beef

15. The packaging of beef products influences my purchase decision.

a) very strongly agree
b) strongly agree
c) slightly agree
d) no opinion
e) slightly disagree
f) strongly disagree
g) very strongly disagree

16. I would be as willing to purchase dark red ground beef as I would be to purchase bright red ground beef.

    a) very strongly disagree
    b) strongly disagree
    c) slightly disagree
    d) no opinion
    e) slightly agree
    f) strongly agree
    g) very strongly agree

17. I think dark red ground beef is as fresh as bright red ground beef.

    a) very strongly agree
    b) strongly agree
    c) slightly agree
    d) no opinion
    e) slightly disagree
    f) strongly disagree
    g) very strongly disagree

18. I think dark red ground beef has the same high quality as bright red ground beef.

    a) very strongly disagree
    b) strongly disagree
    c) slightly disagree
    d) no opinion
    e) slightly agree
    f) strongly agree
    g) very strongly agree

19. I would be willing to pay the same price for dark red ground beef as for bright red ground beef.

    a) very strongly agree
    b) strongly agree
    c) slightly agree
    d) no opinion
    e) slightly disagree
    f) strongly disagree
    g) very strongly disagree

DEMOGRAPHIC INFORMATION

In this section, we want to ask you about some background characteristics. We are interested in seeing how different types of people answered the questions throughout the study.

1. What is your age?

   a) under 18
   b) 18-24
   c) 25-34
   d) 35-44
   e) 45-54
   f) 55-64
   g) 65 and over

2. Your sex is?

   a) male
   b) female

3. What is the last year of school you completed?

   a) grade school/middle school
   b) high school
   c) vo-tech
   d) some college
   e) college graduate
   f) graduate school

4. What is your occupation? Please list.

   _____

5. What was your total household 1983 pre-tax income level?

   a) under $5,000
   b) $5,000-$9,999
   c) $10,000-$14,999
   d) $15,000-$19,999
   e) $20,000-$24,999
   f) $25,000-$29,999
   g) $30,000-$39,999
   h) $40,000-$49,999
   i) $50,000 and over

6. Describe your household.

   a) young, single
   b) young married couple, no children
   c) young married couple, with youngest child under six
   d) married, with youngest child over six
   e) older, married, no children
   f) older, single

APPENDIX 3

Consumer Educational Information

When ground beef is exposed to air it will lose its fresh color. The vacuum-seal wrapping used for packaging red meat products, keeps air away from freshly cut beef. The wrapping usually used for packaged beef does not keep air away. Thus, vacuum-sealed beef will be fresher than the same beef conventionally wrapped.

You can see the freshness for yourself!

Dark red is the natural color of fresh beef before it has been exposed to air. Once beef is exposed to air, it turns a bright cherry-red color. Most people associate this cherry-red meat color with freshness. Actually, dark red meat is the freshest. So, when first cut, beef is dark red. As it is exposed to air, it turns bright cherry-red, and finally, after a few days it turns brown. So, when air is kept away from the beef by vacuum packaging, the beef is dark red and is freshest.

APPENDIX 4

Randomization of Sample Presentation

Order of Sample Presentation:

AAB	BAA	BAB	ABB	BBA	ABA	BBA	BAB
BAA	BAB	ABB	BBA	ABA	AAB	ABB	ABA
BAB	ABB	BBA	ABA	AAB	BAA	AAB	BBA
ABB	BBA	ABA	AAB	BAA	BAB	ABB	AAB
BBA	ABA	AAB	BAA	BAB	ABB	ABA	BAB
ABA	AAB	BAA	BAB	ABB	BBA	BBA	BAA
BAB	BBA	AAB	ABA	ABB	BAA	ABB	AAB
BAA	BAB	BBA	ABB	AAB	ABA	BAB	AAB
BBA	AAB	BAA	ABA	BAB	ABB	ABB	ABA

where: A=vacuum packaged

B=polyvinyl chloride packaged

APPENDIX 5

Triangle Test Ballot

Date _____ Sample ____

Name _____

TRIANGLE TEST

You will be given 3 ground beef samples to taste. Two of the samples are identical, one is different. Please taste the samples in order, from left to right, rinsing your mouth with water between samples.

Indicate below which sample has a different beef flavor than the other two.

____ The sample on the left has a different beef flavor.
____ The sample in the middle has a different beef flavor.
____ The sample on the right has a different beef flavor.

How large is the difference?

____ very large
____ large
____ slight
____ very slight
____ no difference

Comments:

Thank you for your help.

APPENDIX 6

Preference Test Ballot

PREFERENCE TEST

PART I

You will be given two ground beef samples to evaluate. Please taste the samples in order, the one on the left first, rinsing your mouth with water between samples. Please check below how much you like or dislike the beef flavor of each one.

841		372	
___	like extremely	___	like extremely
___	like very much	___	like very much
___	like moderately	___	like moderately
___	like slightly	___	like slightly
___	dislike slightly	___	dislike slightly
___	dislike moderately	___	dislike moderately
___	dislike very much	___	dislike very much
___	dislike extremely	___	dislike extremely

Comments:

PART II

Some people smell their ground beef before cooking it. Do you normally smell your ground beef before cooking it?

___ yes
___ no

Please cut off the top of each of the ground beef packages and smell the meat. Indicate below if you would cook and eat the sample.

458		291	
___	yes, I would	___	yes, I would
___	no, I would not	___	no, I would not

Comments:

APPENDIX 7

Carcass Characteristics of Products Evaluated by Flavor Profile Panel

Animal	#	Sex	Weight	Age	Grade	Quality	Days of Display PVC	Days of Display VP
A	36K	Heifer	660	A	2.5	C-	1	3,8,10,15, 22
B	26RS	Steer	713	A	1.8	G-	1,3,3	1,15
C	35K	Heifer	727	A^{50}	3.3	--		13,13,15
D	332	Bull	640	A	1.6	S++	3,5	10,24
E	37	Steer	947	A^{70}	3.4	C^{40}	3	10
F	9	Heifer	630	A^{30}	3.3	C^{43}		10
G	36	Bull	645	A^{40}	1.3	$S+^{75}$	3,5	14,14

FLAVOR, AROMA AND COLOR INFLUENCES ON CONSUMER ACCEPTANCE AND FLAVOR PROFILE ANALYSIS OF POLYVINYL CHLORIDE AND VACUUM PACKAGED GROUND BEEF

by

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1985

Questionnaires were completed by 1750 grocery shoppers to determine the effect of product color and educational materials on purchase intent for vacuum packaged (VP) ground beef. Each participant examined three ground beef packages, presented in a random order: a polyvinyl chloride (PVC) packaged sample in the bright cherry red oxymyoglobin pigment form; a PVC packaged sample in the brown metmyoglobin pigment form; and a VP sample in the purple-red reduced myoglobin pigment form. Half the consumers received product information (informed). Informed consumers were more likely ($P<.0001$) to indicate a positive purchase intent for VP ground beef than uninformed consumers. Purchase intent for bright cherry red PVC packaged ground beef was lower ($P<.0001$) for informed consumers than for the uninformed group. Educational materials did not appear to have an effect ($P>.10$) on purchase intent for brown PVC packaged ground beef. Informed consumers were as likely to purchase the purple-red VP product as the bright cherry red product they are accustomed to purchasing. Consumers (74%) indicated that color was important in their product purchase intent decision. Color (35%) and amount of fat (38%) were reported as the two single most important factors to the participants when selecting ground beef.

In a second consumer study, VP ground beef was compared to PVC packaged product to determine if cooked flavor differences existed and to determine cooked flavor and raw aroma preferences. Beef trim from steer carcasses was ground and packaged 12 da and 3 da prior to testing for VP and PVC samples, respectively. Triangle testing by untrained consumers indicated that the samples had a different ($P<.01$) beef flavor. Comments indicated that the VP sample was "fresher" tasting and did not have the "off notes" associated with the PVC sample. Degree of difference between

the samples was slight. Subsequent preference testing indicated that untrained consumers preferred ($P<.01$) the flavor of 3 da PVC ground beef over 12 da VP ground beef. Mean scores for the two products were similar, indicating that both products were "slightly" to "moderately" liked. Seventy percent of the participants said they would cook the PVC product based on its raw aroma, 49% would cook the PVC product. The typical 'sour' odor frequently associated with VP beef did not adversely affect the consumer's decision to cook the product.

In a third study, via flavor profiling, the flavor changes ocurring during display were described and quantified so that VP and PVC packaged ground beef could be compared. Triceps brachii and infraspinatus muscles from steer, heifer and young bull carcasses was ground and packaged 1 to 5 da and 1 to 24 da prior to testing for PVC and VP samples, respectively. A seven member trained flavor profile panel was further trained by the panel leader who was familiar with the products. Panelists were trained to observe and record the aromatics, basic tastes, mouthfeel and aftertastes and their intensities as associated with cooked PVC and VP ground beef. After evaluation of a sample was completed, the panel members discussed their scoring, providing a word description of the product to supplement the scale score. VP samples displayed to 24 da had a more constant profile than PVC samples displayed to 5 da. The initial beefy, fresh impact of VP samples after 1 and 3 da display declined slightly during display. The beefy note became briefer and was replaced by a lingering sourness. Bloody/serumy notes changed to metallic/sharp notes after 8 da display. PVC samples lost their beefy, fresh, bloody/serumy notes quickly. After 3 da display, the samples were bland with a threshold amount of staleness. At 5 da display, beef intensity of the PVC samples was very low as was

freshness. Bloody/serumy was not detected and blandness was replaced by a lingering stale note. The discriptors which most effectively explained flavor differences between 3 da PVC and 8-15 da VP samples were: beefiness, freshness, stale/off, bloody/serumy, metallic/sharp, and sour tastes, and metallic mouthfeel and aftertaste. In addition to all the above descriptors, fat flavor, oily and astringent mouthfeel, and oily and stale aftertaste helped describe the changes in the PVC products between 1 and 5 da display.