

Sensory aspects of consumer choices for meat and meat products

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Abstract

The topics discussed in this paper are the changing demand for meat and the factors that influence this demand. These factors include increased health concerns, change in demographics, the need for convenience, changes in the distribution of meat, and price. Finally, the paper covers the meat industry's need for understanding the consumer and the measurement methods used to assess consumer preferences.

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1. Introduction

A national food survey in the UK indicates that beef and veal consumption fell from an average of 175 g per day in 1990 to 145 g per day in 1997 (Ministry of Agriculture, Fisheries and Food, 1991, 1998). The decline in consumption in the UK reflects consumer concerns about the safety of beef as a food, animal welfare and environmental perceptions of beef production, consumer concerns about diet and health, changing consumer lifestyles, and the availability of more conveniently prepared foods.

Changing consumer demand in the US has influenced the market for all types of meat. The change that has the largest potential for challenging traditional American agricultural institutions in recent years has been the dramatic weakening in beef's competitive position. American beef has been gradually losing market share to competing meats and other protein sources throughout the western world.

Since 1970, US per capita consumption of beef decreased from 84 pounds per year to 62.5 pounds per year; chicken consumption increased from 40 pounds per year to 62.5 pounds per year while pork consumption has remained stable at about 47.8 pounds per year (USDA/ERS, 2002).

2. Changes in consumer preferences

Overall, per capita consumption of red meat and poultry has not changed significantly, but when beef, pork, and chicken are examined separately, beef appears to be losing market share to chicken. The negative trend in beef per capita consumption coupled with the increase in capita consumption of chicken indicate that beef must now compete more directly for each dollar spent on meat than was the case 20 years ago. Survey results clearly show that US consumers do not perceive beef as being competitive with chicken in terms of offering low-fat and low cholesterol product lines. A study completed by Menkhaus, Colin, Whipple, and Field (1993) report results indicating that consumer concerns regarding beef were related to cholesterol, calorie content, artificial ingredients, convenience characteristics (microwaveable and storage), how beef is displayed in the store, and price (too expensive). Each of these factors exhibited a statistically significant negative effect on the quality perception of beef compared to other meats.

2.1. Factors changing the demand for meat

In a study consisting of a series of focus groups and conjoint analyses conducted in four countries: France, Germany, Spain and the UK, the most important quality aspects of beef were: that it tastes good, is tender, juicy, fresh, lean, healthy and nutritious (Grunert, 1997). In the US, consumer concerns were related to

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cholesterol, calorie content, artificial ingredients, convenience characteristics and price.

Among the most important factors influencing the changes in consumer demand for meat and meat products in the USA are: (1) increased health concerns, (2) change in demographic characteristics, (3) the need for convenience and increased eating away from home, (4) change in distribution, and (5) change in relative prices (USDA/ERS, 2002).

Product development and innovation are necessary to offset the growth in the availability of food products competing for disposable income. The red meat industry is now in a mature stage, where product development and innovation is necessary to bring about significant growth. As a result of the changes in the demand for meat, interest in new red meat products, particularly convenience-oriented products, has dramatically increased in recent years. To develop these types of products effectively, one must evaluate consumer perceptions and understand consumer preferences.

2.2. Health concerns

An emphasis on nutrition and health, mainly diet, saturated fat, cholesterol and obesity by consumers in the United States has changed the demand for food products, especially meats. Health conscious consumers associate diet with the probability of experiencing health problems or diseases such as high blood pressure, cancer, and heart disease. Increased health concerns have resulted in a shift away from high-fat, high-protein diets to a trend of more fresh vegetables and fruits in the American diet. Veal, beef, and lamb, on the other hand, have experienced significant declines in consumption over the same period.

2.2.1. Fat content of meat

The US marketing of beef has changed relatively little over the last 20 years. Most beef carcasses are cut into products which are grouped either as prime, choice, or select grades. Cattle feeders get a higher price for prime and choice cattle than select. Moreover, feeders tend to put more fat on animals to achieve the prime and choice grades which increases feed costs. By encouraging feeders to produce excess fat, the grading and pricing system has increased production costs and caused feeders to produce a product conflicting with consumers' preferences for leaner beef. Nutritional concerns about fat and cholesterol have encouraged production of leaner animals, the closer trimming of outside fat on retail cuts of meat, the marketing of lower-fat ground meat and processed meat products, and consumer substitution of poultry for red meat—significantly lowering total meat's (including poultry and fish) contribution to the food supply. The proportion of saturated fat contributed fell from 37 to 26%.

2.2.2. Production of leaner animals

The meat industry is working steadily to reduce the fat content of red meat achieving significant results (Higgs, 2000). A shift from the very fat breeds like Hereford and Angus to the bigger, rangier, less fat, faster growing exotic breeds led to the inconsistent, less tender, less juicy, less succulent products. By 1995, one of four steaks was “too tough to chew” according to the 1995 National Beef Quality Audit (USDA/ERS, 2002).

In the 1990s, pork contained more lean and less fat. Improved breeding and husbandry practices and greater trimming of outside fat on retail cuts has lowered the fat content of pork by more than 30% since the 1970s. The US pork industry has capitalized on this by portraying pork as a light and nutritious alternative to chicken with the “Pork: the other white meat” advertising campaign launched in 1997 which focused on leaner and lower fat cuts. Research indicates that consumers are now less likely to perceive pork negatively in terms of fat, calories and cholesterol than before the advertising campaign began.

2.3. Appearance factors

Appearance determines how consumers perceive quality and significantly influences purchasing behavior. In the study of four European countries (Grunert, 1997) the most important product characteristic which consumers base their quality evaluations on are the appearance attributes: fat content and color. Fat is perceived as negative as are all aspects associated with fat, whereas the positive aspects of fat such as flavor and tenderness are not perceived as important.

2.3.1. Visible fat

The effect of high levels of intramuscular fat are detrimental to the purchase of pork loins. The amount of visible fat is the strongest visual cue for consumers considering purchase at retail, indicating that “pork is bad for you” (Levy & Hanna, 1994). Brewer, Zhu, and McKeith (2001) found that highly marbled chops with 3.46% fat appeared lighter colored, less lean, had a less acceptable appearance and were less likely to be purchased by consumers. However, they were rated higher in tenderness, juiciness and flavor than leaner chops in controlled studies. Lean chops and medium marbled chops were selected by 42 and 40%, respectively, by 142 consumers, whereas only 18% preferred highly marbled chops. Overall, appearance acceptability of low- or medium-marbled chops was higher than that of highly marbled chops.

Fernandez, Monin, Talmant, Mourot, and Lebret (1999a, 1999b) demonstrated that increased levels of intramuscular fat in muscle *longissimus lumbarum* could have detrimental effects on meat acceptability by consumers, due to the influence of visible fat on the will-

ingness to eat and to purchase the meat. As long as the fat was not visibly detected, consumers were willing to purchase and eat the meat. In cured, cooked hams, the influence of intramuscular fat on the sensory quality and consumer acceptability was determined. The hams were evaluated by a trained panel of 12 and a consumer panel of 56. Overall, slices with the highest intramuscular fat levels did not have significant effects on the sensory attributes of cured cooked hams, apart from the perception of marbling.

3. Development of low-fat meat products

The development of low-fat products is another strategy to increase the consumption of beef. Continued interest and demand exists for low- and reduced-fat meat products which are being developed in response to health concerns of consumers. Long term acceptance of low- and reduced-fat products was studied by Stubenitsky, Aaron, Catt, and Mela (1999) in an effort to understand the process of change of preference for the sensory characteristics of reduced-fat foods. This information is vital to ensure their commercial success and dietary benefits. Consumer volunteers were given full-fat and reduced-fat pork sausages for consumption at home over a 3-month period. Consumers rated products in home-use tests and in blind sensory tests every month. In blind tests, the reduced- and full-fat sausages received a high rating of acceptability. Results showed no consistent shifts in the hedonic ratings of the reduced-fat pork sausages containing at least 65% meat, compared with the full-fat products over the 12-week trial except for a boredom effect unrelated to acceptance, experienced in their in-home ratings. Findings suggest generally high and sustained consumer acceptance of the reduced fat products tested in normal home use over extended periods.

3.1. Low-fat formulations

The first commercial low-fat formulations were developed by Huffman's group (Egbert, Huffman, Chen, & Dylewski) in 1991. They demonstrated that flavor intensity, juiciness and tenderness of beef are directly related to fat content. Consequently, reduction of fat reduces the overall acceptability of ground beef patties. The first commercial low-fat formulations were made with carrageenan, oat bran or oat fiber and soy isolates. Other ingredients used were starches, maltodextrins, vegetable oil, phosphates and other ingredients (Taki, 1991).

In low-fat ground beef patties (Miller, Anderson, Ramsey, & Reagan, 1993) water and phosphates improved sensory ratings for texture and flavor of 10% fat patties to equal patties with 22% fat. Low-fat

ground beef patties prepared from lower-value raw materials had greater color and oxidative stability than a 20% fat control during 24 weeks of frozen storage (Bullock, Huffman, Egbert, Mikel, Bradford, & Jones, 1994).

Low-fat beef patties can be developed (Berry, 1997) using various techniques such as using beef from young cattle versus old cows or substituting a portion of beef with oat bran and fiber. The substitution with oat bran produced the greatest improvement in tenderness, juiciness and cooking yields.

In the early 1990s, work on acceptable reduced and low-fat sausage systems used added water and carrageenan to low-fat sausages containing 8% fat without deleterious effects on lipid or color stability (Bradford, Huffman, Egbert, & Mikel, 1993). A year later, Osburn and Keeton (1994) developed acceptable low-fat pre-rigor pork sausages, containing 10% fat, with 10–20% konjac flour gel. The sausages had improved cook yields, slightly higher sensory texture attributes, but were rated lower in juiciness. As konjac flour gel levels increased, shear force and sensory textural attributes approached those of a 40% fat control. A study with reduced fat pork sausage patties made with spray dried soy milk found no differences in flavor, but an improvement in texture (Rahardjo, Wilson, & Sebranek, 1994).

More recently, different polysaccharides were studied in low-fat beef sausage (Xiong, Noel, & Moody, 1999) who used ι -, κ -, and λ -carrageenans, alginate, locust bean gum, xanthan gum and 50/50 mixtures of locust bean and xanthan gums. They used eight panelists, with 5–20 years of experience, and trained them in three sessions for this study. Panelists evaluated nine attributes: tenderness, juiciness, chewiness, crumbliness, slipperiness, firmness, flavor intensity and mouthfeel using 13 cm unstructured line scales anchored with “extremely low” (=0) and “extremely high” (=5) at each end. They found that none of the gums affected tenderness and juiciness when compared to controls. Sausages containing alginate, 50/50 locust bean/xanthan gum combinations were less crumbly compared to control. The 2.5% salt sausages had higher flavor intensity, were more tender and more springy, juicier and less crumbly than sausages with 1% salt which had no difference in flavor intensity compared to the control. All of the gums increased yield but only the carrageenans did not compromise texture. The authors noted that increased tenderness may be desirable to some, but loss of bind, and increased crumbliness make the products unacceptable. Unfortunately, no consumer acceptance tests were conducted. Consumer tests may be used to indicate the limits at which loss of bind and product crumbliness caused the product to be unacceptable.

The evaluation of binders and fat substitutes in low-fat frankfurters was studied by Yang, Keeton, Beilen, and Trout (2001). Their treatments included κ -carra-

geenan, isolated soy protein, modified waxy maize starch, wheat gluten, carrafat, a dairy based gel (DRL), isolated muscle protein and konjac flour. They used eight trained panelists to evaluate internal color, firmness, juiciness, springiness, cohesiveness, spice flavor, foreign flavor and overall palatability using an eight-point category scale with 1 corresponding to extremely gray, soft, dry, mushy, bland and unpalatable; not springy and no foreign flavor. Eight corresponded to extremely pink/red, firm, juicy, springy, cohesive, spicy, palatable and intense foreign flavor. The fat content of low-fat products ranged from 8 to 12.4%, and was reduced by 50% compared to a control with 23.6% fat. Modified waxy maize starch, isolated soy protein, and isolated muscle protein had sensory properties and texture similar to high fat controls; purge loss was higher than control. κ -Carrageenan and wheat gluten resulted in frankfurters considerably different from control. Carrafat, DRL and konjac flour resulted in products considerably different from control and had lower palatability ratings.

Chin, Keeton, Miller, Longnecker, and Lamkey (2000) developed Bolognas containing 2.0% fat using konjac flour, konjac flour/starch blends and konjac flour/carrageenan/starch blends, and soy protein isolate replacements. They used a panel of seven panelists trained over three days. The attributes evaluated were: cure flavor, seasoning, fat flavor, soured, smoke, spice, metallic, astringent, oily mouthfeel, salt, sour, bitter, and sweet. They used the Spectrum intensity scale with 0 for absent and 15 for extremely intense. No consumer tests were conducted by the investigators. They found that increased konjac flour decreased lightness, yellowness and instrumental TPA values. Bolognas containing 1% konjac flour and 2% soy protein isolate had instrumental texture profile analysis (TPA) values and sensory attributes similar to control. Sensory properties of low-fat bologna with konjac flour and starch were more similar to control than those with konjac flour/carrageenan/starch.

In studying light Bologna and fat-free frankfurters, Steenblock, Sebranek, Olson and Love (2001) studied the effects of bleached and high absorption oat fibers at 0 (control), 1, 2, and 3% oat fiber. The fat content of the Bolognas ranged from 9.77 to 10.63% with the control having 9.96%. The frankfurters had 0.54–0.92% fat with control having 0.53% fat. Twelve trained panelists were trained in three 1-h training sessions. A 15-point line scale was used with anchors 0.5 points from each end to evaluate hardness determined with incisors, hardness determined with molars, denseness, springiness, cohesiveness, grittiness and moistness in Bologna; whereas all descriptors were used, except for denseness and gumminess which were deleted, and toughness which was added in evaluating frankfurters. The addition of both types of oat fiber produced greater

yield and lighter, less red color. Bleached oat fiber had less effect on lightness and red color than high absorption fibers. Purge was reduced with oat fiber at 3%. Product hardness increased in Bologna with both fiber types, ranging from 51.67 to 54.23 N, compared to the control value of 50.46 N. The ability of oat fiber to increase moisture retention resulting in increased yield, and modify textural properties by increasing hardness, must be utilized appropriately for each product to retain the sensory characteristics important to consumer acceptability. In this case, appropriate consumer studies can determine at what level the addition of oat bran would compromise consumer acceptance.

Shand (2000) studied low-fat Bologna with normal or waxy starch barley. In his study, carrageenan, soy protein concentrate, potato starch and wheat flour were also studied. He used an “experienced” panel of 11 assessors and trained them for three 30 min sessions. Two types of scales were used. An eight-point scale for firmness, juiciness, cohesiveness, overall juiciness, and off-flavor intensity with a rating of 8 for extremely firm, juicy, cohesive, intense, and not detectable; and a rating of 1 for extremely soft, dry, non-cohesive, bland and strong off-flavor. A six-point scale was used to evaluate saltiness, graininess and greasiness, with a rating of 6 for no detectable saltiness, graininess and greasiness, and 1 for extremely salty, grainy and greasy. He found that all low-fat Bologna had similar cook yield and composition. Purge control was greatest when 4% hull-less waxy barley flour or meal was added to formulations; 4% normal starch barley, wheat flour and potato starch resulted in an intermediate level of purge control, while carrageenan and soy protein concentrate had little effect on water holding and texture. Formulations with wheat flour and waxy barley meal were rated firmest, and those with potato starch required the most force to compress. On most sensory properties waxy barley fractions performed similarly to wheat flour.

4. Demographic influences

A change in demographic characteristics of consumers has led to changes in the demand for red meat. Research suggests that income growth and demographic characteristics affect the number of food items demanded by consumers.

4.1. Income

A Texas A&M and Cornell University study estimate that 10% increase in income is associated with a 0.7% increase in demand for ready-to-eat meals (USDA/ERS, 2002). Ground beef purchases are influenced by demographic characteristics (Berry & Hasty, 1982). They found that households with larger incomes tended to

purchase larger quantities of ground beef per purchase and leaner ground beef compared to lower income households.

4.2. Age

In a study of 198 households, [Berry and Hasty \(1982\)](#) found that older consumers tended to make more frequent purchases of ground beef, bought less ground beef per purchase and selected leaner ground beef than younger consumers. In another study, the expected acceptability and consumption acceptability of meat and other foods were determined in elderly subjects. Significant discrepancies were found between consumption and the expected acceptability for beef, processed pork and rabbit meat, but not for lamb, fish, poultry, veal and pork which were found to be similar. Interviews with older consumers indicated that they expected beef to be tender, however it was described as tough after consumption ([Rousset & Jolivet, 2002](#)).

4.3. Ethnicity

Ethnicity also plays a role in consumer demand for food. Areas with more diverse populations are associated with a more diverse basket of food purchased. Supermarkets with ethnically diverse customers will likely increase their offerings of meat products and vegetables, tailoring new selections to the preferences of their customers.

4.4. Convenience

Changing lifestyles has led to the shift toward more convenience in food preparation. Three-fourths of the women aged 25–54 in the USA are now in the work force, compared to about a half 20 years ago. There is an increase in the sedentary lifestyle. Researchers have found that areas with high rates of women in the work force are associated with a less diverse basket of goods purchased. Households with these characteristics purchase fewer traditional meats, such as roasts, for at-home meal preparation but purchase more prepared products ([USDA/ERS, 2002](#)). Multi-income households, for example, will not pay as much for fresh beef because of the time required in preparation. In general, consumers do little planning of meals ([National Cattleman's Beef Association, 2002](#)). Consumers wait until the last minute to plan their meals; most decisions are made the day of the dinner and at the end of the day. Consumers look at their pantry and their watches; time available and on-hand ingredients drive meal choices. There is a continued need to position meat as a quick and easy solution to fit into consumers' busy lives. Hence, processed beef products in consumer-convenient form and positioned as “quick and easy” will be a growing share of the beef market.

More consumers are choosing to eat away from home or purchase more products that are prepared outside the home or partially-prepared. The two major reasons cited for serving prepared meals at home are “not enough cooking time” and “other uses for my time.” Meal solutions will continue to increase in importance to consumers ([Stouffer's, 1999](#)).

Over the last decade the trend toward convenience food has taken its toll on the meat market, particularly beef consumption. While the poultry category made many attempts to cater to today's time-hungry consumers, there was a void in the fresh meat category for similar offerings.

[Anderson and Shugan \(1991\)](#) demonstrated that a superior product such as beef could lose its relative position as a result of a change in consumer preference for an attribute (convenience) in which the competition (poultry) was actually weaker. Data supported the hypothesis that increased consumer demand for convenience contributed to poultry's success in competing with beef rather than the explanation that increased health awareness is solely responsible.

A large part of the increase in poultry consumption may be due to the poultry industry's catering to consumers through its emphasis on producing value-added convenient products. The poultry industry has been more responsive to the changes in consumer lifestyles than the beef industry by providing products that address health and convenience concerns. Only 34.7% of total processed broilers in 1974 were sold as cut up pieces, a value-added more convenient product compared to whole roasters. By 1989, the share of cut up chicken grew to over 60% and increased to 65.4% in 1999. Further processed products such as patties, fillets and nuggets represented 2.9% of processed broilers in 1981 and have increased their market share significantly since then. The proliferation of chicken products has also increased the demand for chicken, and, in turn, has reduced the market share of other meats such as beef and pork. Much of the positive perception enjoyed by chicken is as much the result of packaging, positioning, and product form as it is the product itself and its pricing. Chicken is an entirely different product in the eyes of consumers than it was 20 years ago, while beef's image is virtually unchanged.

During the last few years, however, supermarkets have started offering a variety of value-added, prepackaged and case-ready meat products. According to the American Meat Institute, while these new products may not dictate the future of the meat department, they will become an integral part of it. Meanwhile, the beef industry that has lagged behind poultry and pork in marketing value-added, convenience items, has increased its efforts to tackle the challenge of meeting the demands of today's time-poor consumers.

In January 1999, the US beef industry launched a new advertising campaign with the tagline “Beef, Its what's

for dinner”. This campaign aims to inform consumers and beef industry channels about the new trend—beef dishes that are fully cooked and ready to microwave and serve in 10 min, including pot roasts, meat loaf and beef ribs. The US beef industry has also funded genetic research which may foster the marketing of brand name fresh cuts that are juicy and more consistent in quality (USDA/ERS, 1998). The purchase of beef is still highly influenced by the perception of its healthiness, safety, tenderness, juiciness and aroma or flavor. These attributes constitute important quality criteria for beef selection and consumption by consumers (Mooney, Kerry, & Troy, 2001).

Members of the beef and pork industries are attempting to make their products more convenient for consumers. The National Cattleman’s Beef Association and the National Pork Producers Council have encouraged and supported development of convenient red meat products. All major red meat processors now offer a variety of convenient, fully cooked, or microwave-ready products. Moving away from selling meat as an unbranded commodity and again emulating poultry processors, beef and pork processors now are differentiating themselves from their competitors by branding their products. These branded products are frequently prepackaged and sold to retailers as “case-ready” meats (USDA/ERS, 2000).

4.5. *Change in distribution*

Changing methods of retailing and presentation of meat have made an influence in recent years. Today, some consumers purchase food from less traditional outlets. Meat is usually sold in these outlets as self served and are packaged for convenience to the consumer.

From 1990 to 2000, non-traditional retailers increased their share of at-home food expenditures from 13.4 to 24.5%. Non-traditional retailers include warehouse club stores, super centers, mass merchandisers, drug stores and mail order outlets. Super-centers with a full line grocery area and warehouse club stores are the fastest growing segments of non-traditional food retailers. Warehouse club stores and super-centers accounted for less than 2% of at-home food expenditures annually until the 1990s but increased their share from 1.5% in 1990 to 6.3% in 2000. The success of these stores likely results from consumers desire for economy and convenience.

4.6. *Price*

Beef is no longer consumed in the same quantities as it was in the past; but much of this can be attributed to beef’s higher price, relative to other meats. As a result, beef’s share of consumer expenditures has changed little in the past 30 years. In order to successfully expand into

international markets, beef producers must compete on a price basis with other countries and meats for the products consumers desire.

Domestic markets are affected by prices of competing products, as well as the socio-economic changes occurring in the economy at large. Multi-income households, for example, will not pay as much for fresh beef because of the time required in preparation. Hence, processed beef products in consumer-convenient form will be a growing share of the beef market. These market changes suggest that producers must increasingly become product marketers rather than commodity sellers. They must produce specific products for specific market requirements.

5. **Product development and innovation are necessary**

Product development and innovation are necessary to offset the growth in the availability of food products competing for disposable income. The red meat industry is now at a mature stage where product development and innovation are necessary to bring about significant demand growth. As a result of these changes, interest in new red meat products, particularly convenience oriented products has dramatically increased in recent years.

Meat products are similar to food products in that they are developed, produced and marketed to appeal to the consumer. Ultimately, the success of a food product depends on its acceptance to the consumer, who is the user or potential user of the product and thus the one who purchases the product (Moskowitz, 1985).

Those who work on meat products have to be involved in consumer studies to collect and understand consumer response to the food products and variables or factors that are being studied (Cross & Stanfield, 1976) in order to ensure that the meat products will have high consumer acceptance (Munoz, 1998).

5.1. *Restructured meat products*

The value of red meat products can be enhanced through restructuring techniques (Akamittath, Brekke, & Schanus, 1990). Restructured meats are prepared using less tender cuts of meat. Product development efforts have resulted in restructured beef roasts (Liu, Huffman, Egbert, & Liu, 1990) which resemble intact cuts of meat in appearance and taste. These involve various boning methods and binders which have an effect on structured beef. Sensory properties of restructured beef steaks was determined by Carter, Plimpton, Ockerman, Cahill, and Parrett (1992) using a descriptive panel. The oxidative stability of restructured beef roasts was studied by (Kim and Godber, 2001).

Three hundred consumers were used by Berry, Smith, Secrist, and Douglass (1988) to evaluate restructured

beef steaks with 10–30% connective tissue. Various amounts of connective tissue was added to study its role in the texture of the products. Products with 10–20% connective tissue added were acceptable. In steaks with 30% connective tissue, consumers observed decreased juiciness and overall acceptance. Consumer acceptance of steaks with the low, high and extra high amounts of connective tissue decreased with the amount of connective tissue used.

Ruiz, Higginbotham, Carpenter, Resurreccion, and Lanier (1993) prepared restructured meats from 10 major muscles carefully excised from choice square-cut chucks, yield grade 2. These were classified according to three muscle groups. Group 1 was composed of the most tender muscles and contained the *infraspinatus*, *longissimus*, and *triceps brachii*. Group 2 contained intermediate tenderness muscles and was composed of the *serratus ventralis*, deep pectoral and complex. Group 3 contained the least tender muscles and was composed of the *biceps brachii*, *supraspinatus*, *rhomboideus*, *trapezius*, deltoids, and neck muscles. A consumer panel evaluated acceptance of tenderness, flavor, overall preference, and intent to purchase the product.

There were no differences detected by consumers among the muscle groups on sensory quality. Tenderness and flavor were rated equal to intact steaks for all muscle groups studied. The consumer panel indicated that they would purchase steaks from groups 1 and 2 twice a month and from group 3 once a month.

More recently, Shao, Avens, Schmidt, and Maga (1999) prepared restructured steaks with 5% fibrinogen/0.25% thrombin, 0.5% algin/0.5% calcium lactate, or 0.5% phosphate/1.5% salt. A panel of seven members had 2 days of training to evaluate internal color, binding strength, overall appearance, aroma, taste, tenderness and juiciness using a nine-point hedonic scale. The phosphate/salt and algin/calcium lactate systems had higher cooked yield than fibrinogen/thrombin. Overall quality of the algin/calcium lactate steaks was rated highest, followed by the phosphate/salt and fibrinogen/thrombin. Tenderness, juiciness and taste of the steaks with phosphate/salt was rated higher than the algin/calcium lactate followed by the fibrinogen fibrin control.

5.2. Low-salt products

Low-salt products would satisfy the needs of certain populations. In Finland, Ruusunen, Sarkka-Tirkkonen, and Puolanne (1999) studied how the salt (NaCl) content of cooked Bologna-type sausages can be reduced without violating the perceived taste pleasantness. The panel of 34 assessors evaluated seven cooked sausages with added salt concentrations of 1.05, 1.20, 1.35, 1.50, 1.65, 1.80 and 1.95%. The consumers were able to rank the sausages in the right order of saltiness. Pleasantness ratings were not different for 1.35–1.95% formulations. The authors

concluded that reduction of added salt to 1.35% is possible. In Finland, products labeled “low-salt” should have less than 1.3% based on chloride analysis.

5.3. Vacuum-packaged meats

Vacuum-packages are easy to handle. Consumers generally perceived vacuum packages as easy to handle and store. Vacuum packaging may prevent the need for short-term frozen storage. Consumer acceptability of vacuum-packaged (VP) pork roasts was studied by Oreskovich, McKeith, Bechtel, Novakofski, and Hudson (1986), who used the home placement test method. Over 80% of participants preferred the color and overall appearance of roasts wrapped in PVC overwrap; only six of the 51 respondents ranked VP pork superior in color. VP removed oxygen and results in a dark red or purple color. This finding is supported by Wachholz, Kauffman, Henderson, and Lochner (1978) who reported that the majority of consumers will select pork that is a normal pinkish red color, discriminating against pork that is too light or too dark.

Odor, flavor and tenderness was not different between the two packaging materials (PVC vs VP). Forty-two percent of consumers rated the VP product superior to the PVC; 38% rated both product equally acceptable. Acceptance of vacuum-packaged meat offers new opportunities for developing pre-cooked products for the convenience-oriented consumer. Studies by White, Resurreccion, and Lillard (1988) indicated that consumers' preference for vacuum-packaged steaks held for up to 4 days was not significantly different. After 7 days of storage a TBA value of 8.4 was reached, preference was significantly lower.

5.4. Sous vide products

The sous vide process of vacuum packaging food before applying low (below 100 °C) temperature thermal processing and storing under chill conditions (0–3 °C) is considered to offer enhanced quality and extended shelf life (Armstrong & McIlveen, 2000). Improved flavor, due to vacuum packaging which prevents the development of oxidative off-flavors, and texture particularly meat tenderness and juiciness has been reported. Red meat products have been reported to retain their sensory quality for 23–35 days (Hansen, Knochel, Juncher, & Bertelsen, 1995). There is a lack of standardization in definition of systems, objectives and experimental methodology used (Mason, Church, Ledward, & Parsons, 1990) making comparisons difficult. This lack of reliable and consistent information on sensory quality of *sous vide* products may be an explanation for the low market penetration and adoption of *sous vide* in the UK, North America and elsewhere (Armstrong & McIlveen, 2000).

Two *sous vide* dishes, bolognaise meat sauce containing a steak mince and a chicken dish containing diced chicken were processed at 70 °C for 900 min and 90 °C for 45 min, respectively, then stored at 1.5 °C and assessed at regular intervals up to 40 days. Trained panels of 12–13 assessors using the QDA method and laboratory consumer panels with 40 panelists indicated that the products retained their level of sensory quality and acceptance throughout the 40 days. The trained panelists rated 19 or 16 descriptors for the bolognaise or chicken, respectively, using 150 mm line scales. Consumer panels rated samples using nine-point hedonic scales (Peryam & Pilgrim, 1957) from dislike extremely to like extremely for aroma, appearance, flavor and texture. The critical attribute which determined consumer acceptance of these meat-based *sous vide* products is appearance. The study indicated that the process can produce perceived “fresh”, convenient, high quality refrigerated foods with extended shelf life for up to 40 days. Findings of this study also indicate that *sous vide* technology has the capability to satisfy consumer demands for acceptable sensory quality beyond that of other cook-chill technology (Armstrong & McIlveen, 2000).

6. Understanding the consumer

Product development efforts have resulted in more failures than successes. Much of the blame for the frustrating high rate of product failure lies in not understanding the consumer. Sensory testing can help the product development team decipher what the consumer means. Consumer affective tests are necessary for better understanding the language of the consumer. Consumer affective tests are those that ask for preference and acceptance. Trained panels have their place in food product development but will not tell you about consumer acceptance.

Consumer tests may be classified according to the location of the test. These are laboratory tests, central location tests (CLT), and home-use tests (HUT) or home-placement tests (Resurreccion, 1998). Laboratory tests are conducted in research or research and development laboratories. Central location tests are more commonly used by industry. Special types of CLT are conducted by using a mobile laboratory or a mobile cart (Stone & Sidel, 1993). Home-use tests are conducted in consumer’s homes.

Laboratory tests allow the use of highly controlled conditions during preparation of samples and testing conditions. Central location tests are usually conducted where large numbers of consumers can be intercepted to evaluate samples. In instances when a large number of people are needed, but more stringent controls over that of the retail environment are required, a mobile labora-

tory provides a suitable solution. Consumer purchase behaviors can be evaluated by using supermarket simulation studies. Details on the methodology for each of these consumer tests may be found in Resurreccion (1998).

7. Summary and conclusions

Accompanying the decreasing demand for beef is the increasing demand for chicken. Several factors influencing the changes in consumer demand for meat include: health concerns, changes in demographic characteristics, the need for convenience, changes in distribution and price. Quality, defined as consumer acceptance of a food or food product by regular consumers of the product, can be quantified by using consumer affective tests and characterizing sensory properties of the product using sensory descriptive analysis ratings or physicochemical measurements. Consumer preferences for meat, from a sensory stand point are influenced by appearance, tenderness, flavor, and juiciness. Purchase intent or willingness to buy is likewise important in determining preferences. The relation can be determined by plotting acceptance ratings against the descriptive analysis ratings or the physicochemical measurements. Mathematical models may be developed that can be used to predict consumer acceptance scores from descriptive analysis ratings or physicochemical measurements. These equations may be used to establish specifications for food products that correspond to a predetermined degree of quality. Multivariate statistical techniques allow better integration of data collected from consumer affective tests, sensory assessment by trained panels and physicochemical tests (Resurreccion, 1988). The use of these techniques has resulted in advances in finding out what the consumer wants and likes.

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