CONTRIBUTION OF MEAT TO HUMAN HEALTH[1)]

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ABSTRACT

Meat is an outstanding source of protein with high biological value. It is also an excellent source of the B vitamins, and of the minerals iron, zinc and phosphorus. Even though meat is an excellent and satisfying nutritional substance and thereby contributes positively to human health, it has come under increasing attack in recent years by consumer activist groups. Fat, salt and nitrite are three specific arears, regarding meat and meat products, in which an attempt has been made to relate meat consumption by humans to development of degenerative diseases. The specific evidence to support these claims is weak. Nevertheless, societal concerns and life-style patterns have resulted in a declining consumption of red meat. Survival of the meat industry depends upon imaginative and vigilant research together with objective education of consumers.

INTRODUCTION

The title of this manuscript is simple and appears to be quite straight-forward. However, as I began to consider it carefully it became increasingly apparent to me that my Japanese colleagues had asked me to provide some comments about an extremely involved, important and complex topic. What did they have in mind? Already discussed at this 45th ICoMST have been the topics of safety, chemistry and microbiology---all subjects of current and intense interest to the meat industry and to meat eaters. Perhaps the organizers thought the aspect of nutrition would give a good positive note to the closing the conference. Nevertheless, it has become my task to organize and present some information about the title, to weigh the differences of opinion which exist and then to come forward with some conclusions. My aim is not to generate a literature review but rather to analyze trends in the industry so that an understanding of meat in human health can be sought.

I decided to present at this early stage a simple overview of what I believe has happened in regard to the broad topic of meat and human health during the one hundred year time frame of the Twentieth Century. During the first one-half of the Century there was a positive attitude about the contribution of meat to human health and a great deal of research established the unqualified nutritional benefits of consuming meat. Research also resulted in advancements in preservation of meat so that it could be utilized more widely; and educational efforts informed consumers not only of nutritional benefits but also of safe-handling and preparation procedures. The second one-half of the Twentieth Century saw the development, unfortunately, of a negative attitude about meat and human health.Perhaps this can be explained best as a "positioning" by various groups and interests. Research efforts swung more to analytical detection on one hand and epidemiological aspects on the other. A cause and effect between meat consumption and chronic degenerative diseases was searched for incessantly. Educational efforts became more like sponsored campaigns.

Meat comprises two broad categories---fresh and processed, and both are considered herein. Fresh meat is perishable and requires heating prior to consumption; it is also known as "not-ready-to-eat". Processed meat has added nitrite and salt together with other functional ingredients and seasonings and has usually undergone some degree of heat processing; it is known also as "ready-to-eat", but is often reheated prior to consumption.

The examples I will discuss in this manuscript are based primarily on occurrences in the USA. Nevertheless, I believe the trends described can be extended to other countries---obvious differences exists, but global marketing and instant communication have been well-established in the Twentieth Century.

My objectives then are to present some nutritional facts about meat, to describe some influencing factors and trends in the industry and with consumers, to discuss some important issues about meat and health and finally to reach some conclusions about what happened during the Twentieth Century.

SOME "OLD-TIME" NUTRITION

Almost any publication written during or based on information generated during the first one-half of the Twentieth Century spoke in glowing terms about the nutritional benefits of meat consumption. Hinman and Harris(1947) made the following observations about meat as a dietary item. They pointed out that a person could live for one year on a diet consisting entirely of meat.

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1)The author dedicates this manuscript to the memory of A.I.Pearson---a colleague and friend who was scheduled to address the subject of meat and human health.

But then, they quickly followed with the observation that for good health a balanced diet containing all of the basic food items is necessary. They listed protein for building and repairing body tissues, carbohydrates and fats for required heat and energy, minerals for building bones, teeth, blood etc. and for regulating the body, vitamins for promoting growth and health and bulk for eliminating body waste. They then presented charts to illustrate that meat abounds in high quality protein, has energy-yielding fats, important minerals such as iron and a number of vitamins.

During the 1940s and 1950s research provided a complete understanding of the amino acid composition of meat as well as the spectrum of minerals and vitamins present. A great deal of analytical work established nutrient composition for the various species, cuts and muscles, as well as the influence of heating and other processing. A good summary can be found in the writing of Schweigert(1987), who was responsible for much of the early analytical work. Likewise, the various editions of the textbook entitled *The Meat We Eat*(see Romans et al., 1994) have devoted a good deal of attention to the nutritional aspects of meat.

The proximate composition of meat varies considerably, but for lean muscle is about 20% protein, 9% fat, 70% water and 1% ash, and has about 160 calories per gram. Heating results in denaturation of protein, evaporation of moisture and leakage of fat. Water, fat and soluble substance may separate from the solids during canning(but all is still contained in the can), and freezing/thawing does little to alter composition except for drip loss.

Meat protein is of excellent quality supplying a high percentage of the essential amino acids, and heating has little effect on the amino acids. Meat protein is also referred to as of high biological value because it contains all of the amino acids required by humans.

Meat is an excellent source of the water-soluble B vitamins, and in fact is the main dietary source for U.S. consumers. Pork, for example, is especially high in thiamin having 5 to 10 times more than other meats. The B vitamins thiamin, riboflavin, niacin, folacin, pantothenic acid, vitamin B_6 and vitamin B_{12} are all essential for humans. There is little of the vitamins A,C,D,E and K in meat although some of the organ meats contain good amounts.

Meat is a good source of the minerals iron, zinc and phosphorus. It is noted that meat is, however, a poor source of calcium. While lean muscle contains only 2 to 3 % fat, the amount can vary greatly depending on species and cut, and about 95% of the fat is composed of glycerol esters of fatty acids. The polyunsaturated fatty acids linoleic and arachidonic are dietary essentials for humans. Even though animal fats are known as "saturated", the saturated fats comprise less than half of the fatty acids present.

The concept of bioavailability has taken on greater importance in more recent years. In general, nutrients in meat are quite available as consumed---especially, for example, iron.

One of the outstanding sources of information about meat, especially nutritional facts, has been the publication *Lessons On Meat* (see anonymous, 1974). Quantitative tabular information is provided and illustrations are given to show what typical servings of meat provide. For example, a 3 1/2 ounce serving of cooked meat provides, of recommended daily allowances, 50% of protein, 10% of calories, 20% of iron, nearly 20% of phosphorus, 30% of thiamin and more than 20% of riboflavin. Two important sources of nutritional information and which undergo continuous updating are: Recommended Daily Dietary Allowances as published by the Food and Nutrition Board of the National Research Council, and the composition of various foods published by USDA and known as Handbook No.8.

INFLUENCES AND TRENDS

The earliest concern about meat was merely obtaining sufficient quantity of it for subsistence. Hunters and gatherers spent most of their time seeking food, and meat was highly desired. Even after centers of population had formed and transportation and industrialization were in place the main interest in meat was just obtaining sufficient quantity of it.

Two major changes occurred during the Twentieth Century. Early in the century there was a shift in emphasis from quantity to quality. As a result of a novel entitled *The Jungle,* published by Upton Sinclair, which raised grave concern about the sanitary conditions being practiced in the meat industry, the Meat Inspection Act of 1906 was passed. Likewise, other foods were regulated by the Pure Food and Drug Act of 1906. Suddenly, consumers were concerned about the quality of their food. As the century wore on great advancements were made in the technology of food, and especially in preservation. The second major change of the century found its origin in the culture and life-style of the 1960s. Concern about big business, concern about the environment and an antitechnology sentiment led to a fear about health related and safety aspects of food---especially meat. Extreme effort was directed at attempting to relate consumption of meat to the development of coronary heart disease and cancer. More recently, a hysteria about foodborne illness has developed. The era of organized consumer groups and fear of food was born.

Consumption Trends: From the early 1960s the per capita consumption of red meat has decreased substantially. While this loss has been balanced in part by increased consumption of poultry, the trend is clear and resulted from the development of a feeling that meat does not fit into the dietary pattern of a healthy life-style.

Role of Governmental Agencies: Regulatory agencies, primarily the USDA in the case of meat, are responsible for insuring a supply of safe food, and also may enter into grading considerations to regulate quality definitions and trade. The Meat Inspection Service was organized to inspect both live animals and meat to insure that diseased or unwholesome meat did not find its way into commercial channels and to consumers. The inspection process has been essentially unchanged from the time it was established in 1906---that is until the past few years as a phase-in of HACCP(Hazard Analysis Critical Control Points)has been mandated. This program is a shift of responsibility to the manufacturer to detect and manage food safety problems. In addition, a sampling and testing program for microbiological pathogens has been instituted. Moreover, another governmental agency(Center for Disease Control) has become involved in meat safety not only because of improved testing and identification of pathogenic organisms but also because of a rapid communication system including individual state agencies.

Labeling format and claims are strictly regulated by Governmental agencies.

Governmental agencies have played a role in another way---they make recommendations about eating patterns. The so-called Food Pyramid generated by USDA replaced their four basic food groups. It recommends that each day consumers have 6 to 11 servings of complex carbohydrates, 5 servings of fruits and vegetables, 2 to 3 servings of milk products and 2 to 3 servings of other protein. Fats, oils and sugars are to be used sparingly. Obviously, the proportion of meat in this recommendations is low. The Nutrition Labeling and Education Act was designed to curb misleading health claims. Finally the School Lunch Act of USDA serves thousands of lunches daily in schools in the USA, using the governmental recommendations. Other highly visible agencies, such as the National Research Council, the American Cancer Society and the Department of Health and Human Services, also make nutritional recommendations.

Role of consumer Groups: Organized consumer groups have had a major impact not only on meat consumption but on being the driving force for changes within the food industry. The consumer movement arose during the 1960s and remains active. An example is CSPI(Center for Science In The Public Interest) which is led by Michael Jacobson. Such organizations are very effective in making their thoughts known to governmental agencies and in distributing their information to consumer networks. Most deal with dietary/nutritional issues and food safety problems and in general talk about "real" food versus "junk"(artificial, processed) food. Food additives, and more recently, microbiological issues come in for a good deal of attention.

Role of Commodity Groups: Examples of such organizations are AMI(American Meat Institute), NPPC(National Pork Producers Council) and NCBA(National Cattlemen's Beef Association). There are many other so-called producer organizations including those on regional and state levels. They function in the areas of promotion of their products, and in sponsoring research and generating informational and educational pieces. Some slogans have come well-known and have undoubtedly helped sales of the meat items. Examples are "The Other White Meat" by NPPC and "Beef--It's Whats For Dinner" by NCBA. Unfortunately, some of the educational material meets with a bit of skepticism as it is generated by a group devoted to selling their product. There is also some danger in fragmenting the overall image of meat when strong promotional activity is directed at individual species. There was an umbrella group(the National Live Stock and Meat Board) that covered beef, pork, lamb and veal, but it has been discontinued.

Sociological Concerns: Production of meat begins on the farm with live animals. Consumer influence has also been felt in this regard. Concern about the environment, animal well-being and genetic engineering has forced changed in production techniques, and will continue to do so in the future.

Education: During the 1940s and 1950s there was good, simple information produced about the nutritional value of meat ---especially as the details about protein composition and the functions of vitamins and minerals were understood. Likewise, there was a strong "Home Economics"program which emphasized not only proper preparation procedures for meat but also good handling practices within the home. Educational efforts now are often tinted with a promotional aspect or unfounded health warnings. More and more products with some degree of pre-preparation have supplanted home cooking. Scientific finding about meat and health are debated contentiously by the promoters and detractors of meat, and the consumer is left with confusion.

ISSUES

The following list deals with issues which have impacted strongly on the contribution of meat to human health. We shall commence with the big three---fat, salt and nitrite, and then continue on with several other important issues.

Fat: In earlier times fat in meat was viewed as an energy source. Likewise, the intramuscular fat content or marbling has been used to judge palatability---the more fat the better the palatability. During the 1960s, however, the mood changed and scientific evidence was interpreted to indicate that the saturated fats found in meat were associated with cholesterol level in the consumer and with coronary heart disease. Subsequently, evidence surfaced to suggest that meat (fat) consumption was associated with some forms of cancer.

The meat industry took up the challenge and waged a "war on fat". Animal geneticists were successful in breeding much leaner animals, and retailers trimmed more fat from retail cuts. Buege et al conducted a survey of retail pork in 1990 and compared the results to information collected prior to 1981. It was found that during the decade of the 1980s the fat content of raw lean from eight representative pork cuts had decreased by 19%. The fat content of loin muscle was in the range of 5 to 6.5%. Follow-up work (Buege et al) on composition of pork and chicken was reported in 1998. Fat and cholesterol content of lean pork was unchanged from previous levels. The fat content of lean chicken meat was 3.9%.

A revolution also occurred in the processed meat industry during the past decade. An entire new category of "low-fat/no-fat" processed meats was developed. Enormous technological advancements were made. Fat replacers (Akoh, 1998) have not found much use in meat products. For the most part fat was replaced with water , and the additional water was held in the product with added carbohydrate. Clearly, the meat industry responded to consumer demands for meat with lower fat content. Where does the situation stand? The dietary goal is to reduce fat intake to less than 30% of calories. To begin with consumers want food with minimal fat but they also want the food to taste good. Meat with low fat often lacks palatability. So, there is somewhat of a conflict. The best advice remains to achieve a balanced diet by using a variety of foods and maintain a physical activity schedule.

Focusing only on fat is not the best solution. There are multiple risk factors for coronary heart disease---for example genetics and obesity. Fat and diet are discussed continuously and at all levels of society. And, any advice desired can be found. Clearly, the meat industry has stepped forward and produced meat with less fat. Why then does the controversy continue at the same level intensity? And, why does obesity continue to plague Americans?

Salt: The issue with salt has been somewhat similar to that with fat. It has been widely thought and recommended that by lowering salt consumption blood pressure would be reduced resulting in better health. People use salt in (on) their food as it is a determinant of taste, just as is fat. Processed meats are a source of salt (sodium chloride), and salt is used as a seasoning on fresh meat. In former times salt was used in meat as the major component of preservation, and it was not unusual to find a level of 6%. As technology improved, and especially as the refrigeration chain came into wide-spread use, the preservative effect of salt became less important and the levels declined to about 3%. As concern about processed meats as a source of salt surfaced and became intense the industry responded again by lowering salt content while shoring up other means of maintaining adequate preservation and thereby minimizing the risk of foodborne illnesses.

The controversy about salt reduction has been vitriolic for nearly three decades.

Governmental agencies have denounced salt as a health hazard and it too has been a common topic of conversation, but there has been a nagging suspicion that the benefits of salt reduction are not really that great. A recent report in Science (Taubes, 1998) provides a keen insight into the controversy and goes under the interesting title of "The (Political) Science of Salt". The article gives a complete historical perspective, but keeps returning to the theme that the salt controversy centers on the conflicts between public health policy on one hand and the requirements of good science on the other. Overall, it is apparent that the contended benefits of avoiding salt have diminished and are not as great as thought originally. The benefit is either extremely small or nonexistent, and there are many confounding influences such as genetics, obesity, physical exercise level, socioeconomic status etc.

Nitrite: The issue about nitrite cured meat was more intense and shorter lived than the issues about fat and salt. During the 1970s the use of nitrite to cure meat was seriously questioned, and a ban was very nearly enacted. The possibility of preformed N-nitrosamines, which are carcinogens, was suggested, and the residual nitrite present added to the total body burden of nitrite in consumers of cured meats. While the controversy and debate continued over a ten year period, there was an enormous amount of research and testing undertaken. In addition, the industry made changes such as lowering ingoing nitrite, using the maximum level of ascobates (which inhibit formation of N-nitrosamines) and improving process control. In this case, however, public concern about cured meat as a human health risk was largely eliminated by the publication of reports from the National Academy of Sciences. A complete history of the nitrite controversy is available in book form (Cassens, 1990).

Some interest in the nitrite issue was restimulated in the early 1990s when a suggestion was made, from epidemiological studies, of a link between some forms of childhood cancer and consumption of nitrite cured hot dogs. These results were discredited scientifically. At the same time it was established that during the intervening 25 year time period the residual nitrite in retail cured meat had declined to about one-fifth of the original level (Cassens, 1997).

The nitrite problem provides an interesting comparison with the those of fat and salt. In all cases, the consumer advocacy groups have played a major role. They have voiced strong opinions, but have had little scientific evidence to back up their opinions. Much of the controversy has swirled around epidemiological (and more recently meta type studies) studies which in fact provide little fact but rather implied suggestions. Governmental regulatory agencies are interposed between advocacy groups and research scientists and in a regulator/regulated association with industry. In regard to food issues, the Governmental agencies have become more involved in

shaping public policy. Science was used to solve the nitrite problem, but the issues surrounding fat and salt continue under debate---this latter probably because the actual issues broad and diffuse compared to the nitrite issue which was much more defined.

Two publications from CAST (Council for Agricultural Science and Technology) give scientifically informed opinions. It is pointed out (Beitz et al, 1997) that food from animals contributes significantly to the total nutrient intake in American consumers, and that the nutrients in those animal products are highly available. There is a forceful rationale for including animal-derived foods in balanced diets. The challenge for consumers is to apply the time-honored principles of balance, variety and moderation by selecting from all food groups. An "Issue Paper" by CAST (Pariza et al, 1997) reviewed the body of scientific information and concluded---the scientific evidence does not support restrictions in the consumption of salted, smoked or nitrite-preserved foods by U.S. population.

CLA: Conjugated linoleic acid is a collective term for positional and geometrical isomers of linoleic acid. While linoleic acid has double bonds between the 9^{th} and 10^{th} carbons and the 12^{th} and 13^{th} carbons, CLA has double bonds at carbon atoms 10 and 12, or 9 and 11, with possible cis or trans isomers. The interesting effects of CLA are that it is anticarcinogenic, antiatherogenic and it induces a decrease in body fat levels and an increase in protein content. CLA occurs in both meat and dairy products. In lamb fat it is found at about 6 mg/g and in homogenized milk it is found at about 6 mg/g fat. Detailed information can be found in Pariza (1997) and in Park et al (1997).

The previously discussed recommendation of eating less animal fat is interesting in view of the purported effects of CLA, which is found in animal fat.

Long-Chain Polyunsaturated Fatty Acids: This group of fatty acids is known as n-3 or n-6 referring to the first methylene interrupted double bond counting from the methyl carbon end. In fish eicosapentaenoic and docasahexaenoic (both n-3) are well known, and arachidonic (n-6) occurs in red meat being in muscle membranes and at a total of less than 1% of wet weight (Addis, 1989; Garcia, 1998). The main interest in these fatty acids is their role in protecting against coronary heart disease. Most research interest centers on feeding n-3 fatty acids so as to incorporate them into meat (ruminants will not deposit them but monogastric animals will), incorporating n-3 containing oils directly into a processed meat, or making a red-meat/fish-meat combination. Stabilizing the polyunsaturated fatty acids is a potential problem.

Heterocyclic Amines: An area of concern has been the possibility that heterocyclic amines are formed during cooking of meat, and they are known carcinogens in laboratory animals. It is known that frying or grilling meat results in detectable levels of heterocyclic amines, but establishing the real risk to consumers will require detailed epidemiological studies. For further information see Knize et al (1998) and Skog et al (1998).

Chemicals: Chemicals occur naturally in foods, may be put in as additives, or be formed during a preparative process such as heating. Most are functional but some are more or less inert, and they are viewed by consumers generally as bad---but some such as CLA are viewed as good. In fresh meat there are essentially no additives allowed, but in processed meats there are numerous. The many new and/or unusual additives used in the category of low/no fat products should be investigated thoroughly. Two unique possibilities exist for incorporating functional chemicals into meat. Incorporating vitamin E into beef muscle by feeding it to the animals has been demonstrated successfully, and the result is a stabilization of the desirable red color in the meat (Faustman et al 1989). The other possibility is through genetic engineering of the animal to produce a specific effect in the meat, a process which to date has not made much advancement.

Substitutes for Meat: Other than the work of nearly 30 years ago wherein simulated meat was made from spun fiber of soy protein, little has been accomplished in this regard. On the other hand, soy products such as tofu are used in many countries as a protein source in replacement of meat. These soy products are also being touted as containing healthy components such as n-3 and n-6 fatty acids (see polyunsaturated fatty acids above) and isoflavones.

Functional Foods: At present, no discussion of nutrition and foods would be complete without interjecting the term "functional food". Hasler (1998) has pointed out that while all foods are functional by providing taste, aroma and nutritive value the so-called functional foods go beyond meeting basic nutritional needs and provide additional physiological benefits. Current interest is high in functional foods for their role in disease prevention and health promotion, and some consider functional foods as providing a health benefit beyond the traditional nutrients contained in it. Greatest interest is focused on functional foods from plant sources. There are few such examples in meat with CLA (discussed above) being one.

Irradiation: Finally, I with to mention a process rather than an ingredient or component. Irradiation has been known as a useful and safe preservative method for meat for more than a third of a Century. However, it has not been adopted for use because of consumer fear.

CONCLUSIONS

Food derived from animals in general, and meat in specific, provides a great nutritional package. Meat furnishes humans with high quality protein containing the spectrum of essential amino acids, the array of required B vitamins and needed minerals such as iron, zinc and phosphorus. In addition, meat tastes good and provides a satiety factor.

During the past one-third century, however, the value of meat to human nutrition has been challenged on three major fronts---fat, salt and nitrite. The case has been put forward that consumption of meat is linked to the development of the chronic conditions of coronary heart disease and cancer. The evidence has been weak. Nevertheless, organized consumer groups have been very effective in promoting such viewpoints, and Governmental agencies have become involved in the public policy of nutrition. A positive viewpoint about meat has been put forward by various commodity groups. In general, the outcome has been a continuing and vitriolic debate.

Research into the issues has been designed often in a defensive nature or taken an epidemiological approach in a search for cause/effect. The result has been more continuing debate. Nutritional advice has been generated and promoted by numerous agencies and organizations.

The industry has responded by lowering fat content of meat, by lowering salt content of processed meat and by making changes that minimize any risk from nitrite cured meat. But, the contentions continue.

It seems clear that the final and ultimate decision falls to the consumer---whether it be merely a personal preference in consumption patterns or a "grass-roots" movement to influence nutrition policy.

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