MEAT AND MEAT PRODUCTS

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Summary

Among mammalian species, the meats consumed by humans are primarily from cattle, pigs, and sheep. Meat quality evaluation starts with the quality control of raw meat obtained after slaughtering. The second step is the estimation of the quality of cooked meat, and the final one is the quality control of meat products. The grading of carcasses (carcass meat) into market categories is generally based on visual assessment. Although some efforts have been made to develop objective methods and quantitative indices, the sensory methods are dominant in the evaluation of such properties as tenderness, juiciness, flavor, odor, and color. The lean meat ratio is measured quantitatively.

In the case of cured meat products, in addition to sensory properties, nitrate and nitrite content should be controlled. In most countries the permitted amount of these compounds is governed by legislation. Concerning canned meat products, uniformity of color, texture, and flavor are important indices of quality. The use of nonmeat proteins and the applicable maximal levels are regulated or standardized.

Regarding safety, the main source of potential health hazards (foodborne diseases) is the contamination of foods with microorganisms. To avoid or minimize microbiological contamination both at national and international levels, codes of hygienic practice have been established. HACCP is also widely used. Meat may contain residues of pesticides and veterinary drugs. The acceptable limits of these contaminants have been regulated worldwide. The characteristics of poultry meat are broadly similar to those of other meats.

1. Introduction

Meat is defined as the flesh of animals used as food. In a narrow sense this definition is restricted to a few dozen mammalian species, but it is often widened to include musculature, organs such as liver and kidney, and the brain and other edible tissues. An even broader definition of meat includes the same parts of poultry. In this chapter the word meat will be used in this broader sense, and does not include fish.

Among mammalian species the meat of cattle, pigs, and sheep is primarily what is consumed by humans. In addition, the flesh of horses, goats, and deer is regularly consumed. Various other mammalian species are eaten in different parts of the world, according to their availability or because of local custom. Thus, for example, seal and polar bear are important in the diet of Eskimos; kangaroo is eaten by Australian aborigines. Rabbit and hare are generally considered separately, along with poultry. Poultry means, according to use in this chapter, any domesticated bird including chickens, turkey, ducks, geese, guinea fowls, or pigeons.

It must be recognized at the outset that, in the production of meat and meat products throughout the world, there are many differences of opinion among farmers, wholesalers, retailers, and the meat manufacturing industry as to what characteristics constitute quality. This is hardly surprising if consideration is given to the widely differing social and eating customs of the world's population and the wide range of meat products manufactured and consumed in different countries. To add to the complexity, legislation relating to meat and meat products varies from country to country.

The definition of quality can be described readily when the product is a simple substance such as sodium chloride, used for curing meat. Purity standards for such materials can be defined and determined with accuracy; the form and size of the salt crystal may be specified and controlled, keeping in mind the complexity of muscle tissue and the changes it undergoes after slaughter.

Distribution, and the fact that final estimation of meat quality is made by the consumer only by eating the cooked meat, makes understandable the difficulties of meat quality evaluation. In every case, meat quality evaluation starts with the quality control of raw meat obtained after slaughter.

The second step is the estimation of quality of cooked meat, and the final step is the quality control of meat products. In the following sections, the main quality indices of meat and meat products will be discussed.

2. Quality Indices of Carcass Meat

The word carcass means the whole body of the animal after stunning, bleeding, plucking, and eviscerating. Cattle and pig carcasses are split along the midventral axis into two sides. Carcasses may be “dressed,” where the head, feet, and hide (in the case of sheep, cattle, and pigs) are separated.

Until the last decades of the twentieth century, it was a commercial practice to chill dressed carcasses prior to preservation or processing and, after chilling, to prepare primal, wholesale cuts from them. Prior to the introduction of vacuum packaging, wholesale cuts were sold with bones intact to avoid evaporative loss and minimize contamination. Now a considerable part of carcasses is de-boned, and delivered to retailers as boneless primal cuts. In the absence of bones, and because meat cuts are less bulky, chilling and freezing can be more rapidly and economically effected.

The grading of carcasses (carcass meat) into market categories is generally made based on visual assessment. Although some efforts have been made to develop objective methods and quantitative indices, the sensory methods dominate in evaluation of such properties as tenderness, juiciness, flavor and odor, color, and so on. What is quantitatively measurable is lean meat ratio. In the European Union, the carcasses are evaluated as I, II, and III, the grade depending on the lean meat ratio being 45% to 55% of the total weight of the carcasses. In the case of pigs, backfat thickness is also measured.

2.1. Quality Characteristics

2.1.1. Texture and Tenderness

Of all the attributes of the eating qualities of meat, texture and tenderness are presently rated most important by the average consumer. It has therefore been suggested that tenderness is the primary essential quality index of meat, and if meat is not tender it may be considered unacceptable, despite other characteristics such as color, flavor, and juiciness. The factors that contribute to tenderness or toughness are still not completely understood. Species is the most general factor affecting tenderness. To some extent this is a reflection of texture (the size and condition of the meat fibers within the muscle, and the relationship between the amounts of muscle fiber and connective tissue. Generally, higher connective tissue ratio means less tenderness. Concerning the role of species it could be stated that large-size cattle, in relation to pigs or sheep, are generally associated with a greater coarseness of musculature.

The connective tissue content of a given muscle also may vary between that of individual cattle or pigs within a breed. In general, increasing age connotes decreasing tenderness. In connection with connective tissue content it should be mentioned that the connective tissue in young animals has a different composition and a looser structure. This is connected with better solubility upon heating of the collagen in young animals, and greater susceptibility to attack by enzymes. There are distinct differences in tenderness between muscles. Muscles that were frequently in use have higher elastin (a type of connective tissue protein) than those that were used less extensively. Even tenderness within a given muscle may vary significantly. For example, there is a systematic decrease in tenderness in proceeding from the proximal to the distal, and of beef semimembranosus. Summarizing the effects of pre-slaughter factors that affect tenderness, those may be estimated by the amounts, distribution, and type of connective tissue. Within a given muscle, however, where amounts and type of connective tissue are constant, there can be considerable differences in tenderness caused by post-slaughter circumstances. The most immediate of these is the post-mortem glycolysis by which glycogen of the muscle tissue is converted to lactic acid. Except when inanition or exercise immediately pre-slaughter has appreciably diminished the reserves of glycogen in the muscle, the conversion of glycogen to lactic acid will continue until the pH is reached when enzymes effecting the breakdown become inactivated.

In typical mammalian muscles, this pH is about 5.4 to 5.5. As post-mortem glycolysis proceeds, the muscle becomes inextensible; this is the stiffening referred to as rigor mortis. The extent of post-mortem glycolysis also has an effect on the tenderness of beef, pork, and lamb. Generally the carcasses are stored for a few days after slaughter. The holding of unprocessed meat above the freezing point is known as "conditioning" or "aging." The decrease in tenderness associated with the onset of rigor mortis is gradually reversed as the time of post-rigor conditioning increases. Conditioning is associated with an increase in tenderness and flavor. The changes occurring during conditioning are connected with the limited proteolysis of muscle proteins. It has been found that water-soluble nitrogen increases, due to the production of peptides and amino acids from protein. Tenderness or toughness, therefore, is a quality that represents the summation of the properties of the protein structure of skeletal muscle, and is necessarily associated with all those factors that may affect muscle and muscle protein, such as growth and development of the animal, breed, nutrition, ante-mortem and post-mortem handling, and methods of cooling, processing, retailing, and cooking.

Attempts to make meat tender artificially are by no means new. They have included beating the meat, cutting it into small portions so that the strands of connective tissue are severed, marinating it with vinegar, wine, or salt, and enzymatic tenderizing. Enzymatic tenderizing was the process that took place when Mexican Indians wrapped meat in pawpaw leaves during cooking, as long as 500 years ago. Such attempts have become more widespread and systematic. At present proteolytic enzyme-containing commercial meat tenderizers are used. Among the enzymes that have been most commonly used in tenderizing meat are bacterial and fungal proteases, and some plant proteases, such as ficin (fig), papain (pawpaw), and bromelin (pineapple). Assessment of tenderness is mainly made by sensory methods. This is connected with the complex nature of the structure of meat and difficulties in objectively reproducing the process of chewing, which is how the consumer evaluates tenderness. The most serious disadvantage of sensory evaluation is the subjectivity of the methods, which makes it difficult, and frequently impossible, to compare experimental results between different laboratories, or even between different sittings of the same panel. Nevertheless, subjective methods of assessment have the advantage of approximating the estimates of tenderness made under normal conditions of eating, and are generally used as a reasonable criterion of general consumer acceptance.

An objective method is clearly desirable, not only to provide a means for routine quality assessment, but also to enable the evaluation of experiments designed to improve tenderness. A number of instruments have been developed for such purposes. Although these instruments provide an objective assessment of one aspect of tenderness and, under certain conditions are useful as analytical tools, nevertheless, none of the objective methods so far devised has succeeded in replacing the human senses in their ability to evaluate and describe meat texture.

2.1.2. Water-Holding Capacity and Juiciness

The water-holding capacity of meat is an attribute of obvious importance. Diminution of the water-holding capacity is manifested by exudation of fluid known as "weep" in uncooked meat, which has not been frozen, as "drip" in thawed uncooked meat, and as "shrink" in cooked meat. Not more than 5% of the total water of muscle (i.e. about 4% of the wet weight) is directly bound to hydrophylic groups of proteins. Most of the observed changes in water-holding capacity involve alterations in the so-called "free" water, which is immobilized by the physical configuration of the proteins, but not bound to them. Studying the factors influencing water-holding capacity, it could be stated that some considerations apply generally to all muscles. Thus, because post-mortem glycolysis in a typical muscle will normally proceed to an ultimate pH of about 5.5—the isolelectric point of the principal proteins of in muscle—some loss in water-holding capacity is an evitable consequence of the death of the animal. Conditioning (aging) of meat increases its water-holding capacity. Apart from these general effects, the water-holding capacity of meat is affected by several other factors such as species, age, and muscular function.

From a practical point of view, one important phenomenon is the occurrence of PSE meat from pigs. The abbreviation PSE is formed from initials of the words pale, soft, and exudative. Such meat has a pale color, is relatively soft, and has reduced water-holding capacity. This means that the uncooked meat has a bright fluid loss (weep). Its losses during cooking are high. Occurrence of PSE meats is the consequence of the increased rate of post mortem glycolysis, causing the rapid drop of pH, and structural changes in muscle proteins. Comminuted meats are on the one hand more liable to exude fluid because the original structure of muscle is destroyed. On the other hand, the nature of products prepared using comminuted meat permits direct manipulation of the meat to enhance its water-holding capacity. Increase of the water-to-meat ratio by water addition increases the overall water-holding capacity of the mix. Sodium chloride added to the mix also enhances water-holding capacity. Certain salts of weak acids, in particular phosphates and polyphosphates, are also added to comminuted meats to enhance water-holding capacity. Such treatments result in the high water content of some types of sausages. It is difficult to give a definition of juiciness. The sensation of juiciness is composed of two organoleptic components. First is the impression of wetness during the first few chews produced by the rapid release of meat fluid; the second is a sustained juiciness largely due to the stimulatory effect of fat on salivation. Tenderness and juiciness are closely related and, in general, the more tender the meat, the more readily juices appear to be liberated during eating. To date, sensory assessment appears to be the only practical way of measuring this quality.

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Bibliography

Bolton D.J., Oser A.H., Cocoma G.J., Palumbo S.A. and Miller A.J. (1999). Integrating HACCP and TQM Reduces Pork Carcass Contamination. *Food Technology* **53**, 40–43. [Interesting information about safety control in industrial practice.]

Codex Alimentarius Commission. *Recommended International Standard for Cooked, Cured, Chopped Meat*. [An example of a standard adopted by the Codex Alimentarius Commission.]

Codex Alimentarius Commission (1976). *Recommended International Code of Hygiene Practice for Poultry Processing*. CAC/RCP 14-1976.

Doyle M.E., Steinhart C.E. and Cochrane B. (1994). *Food Safety 1994*. NewYork/Basel/Hong Kong: Marcel Dekker Inc. [An excellent review of food safety problems, interesting also for nonspecialists in this field.]

Fellows P. (1990). *Food Processing Technology, Principles and Practice*. New York: Ellis Horwood Ltd. [This book gives basic information about processes used in food production.]

Fennema O.R. (1985). *Food Chemistry*. New York/Basel, Marcel Dekker Inc. [Information about chemical composition of foods and properties of their constituents.]

Herschdoerfer S.M. (1968). *Quality Control in the Food Industry*. London, New York: Academic Press. [A well presented, easy to understand summary of food quality control.]

Lawrie R.A. (1985). *Meat Science,* Fourth Edition. New York, Oxford: Pergamon Press. [A high-level overview of the scientific basis of meat processing and its quality control.]

Williams A.A. and Atkin R.K. (1983). *Sensory Quality in Food and Beverages*. New York: Ellis Horwood Ltd. [A book dealing with the importance of sensory evaluation in the food industry.]

Biographical Sketch

Radomir Lásztity, D.Sc., Professor of the Department of Biochemistry and Food Technology at Budapest University of Technology and Economics, was born in 1929 in Deszk, Hungary, and completed his studies in 1951 at the Faculty of Chemical Engineering of the Technical University of Budapest. Dr. Lásztity received his M.Sc. degree in Chemical Engineering in 1951 and his D.Sc. degree in Chemical Science in 1968.

Dr. Lásztity is honorary president of ICC (International Association for Cereal Science and Technology). He was Chairman of the Codex Committee on Methods of Analysis and Sampling of the FAO/WHO Food Standard Program in the period 1975–1988. Dr. Lásztity is a member of the Food Division of the Federation of European Chemical Societies, and a member of the editorial boards of several international scientific journals. He was Vice-Rector of the Technical University from 1970 to 1976.

Among other awards, he has received the Bailey and Schweitzer Medal of the ICC, the State Prize of the Hungarian Republic, and the Golden Medal of the Czech Academy of Sciences.

Dr. Lásztity's main research activities are the chemistry and biochemistry of food proteins, food analysis, and food control. The results of his research work were published in more than 700 papers in foreign and Hungarian journals. He is the author of more than 20 books and textbooks (among them: *Chemistry of Cereal Proteins*, First and Second Editions in 1984 and 1996, respectively; *Amino Acid Composition and*

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