RECIPROCATION SESSION

Similarities and Differences between Avian and Mammalian Muscle in Growth and Processing

Denise M. Smith and Matthew E. Doumit*

There are many similarities between the growth and processing of avian and mammalian skeletal muscles. These similarities have been recognized over the years and it is now common for large meat processing companies to prepare value-added meat products from avian and mammalian species under the same roof. Research and development staff work to develop further-processed products from multiple species, often using two or more species within the same product. For example, it is not uncommon to find frankfurters containing turkey, pork, and beef. There are some important differences between avian and mammalian muscles that must be taken into consideration to optimize the quality and yield of poultry, beef, and pork products. Our presentation will describe some of the important similarities and differences during growth, slaughter, and processing of beef, pork, and poultry.

The cellular events of mammalian and avian embryonic muscle development are similar. In early stages of muscle development, mesodermal stem cells give rise to embryonic myoblasts. Myoblasts proliferate and subsequently withdraw from the cell cycle, activate muscle-specific genes (differentiate), and fuse to form multinucleated myotubes. Muscle cell differentiation is controlled by expression of myogenic regulatory factors. Although homologous factors have been identified in mammalian and avian muscle, expression of these factors follows a different pattern in mammalian and avian species (Ivarie, 1993). Primary and secondary myotubes synthesize myofibrillar proteins that assemble as myofibrils. Species differences in protein isoforms expressed during development have been documented, yet the functional significance of these isoforms in the embryo is unclear. Embryonic muscle fiber development in mammals has been manipulated by hormonal and nutritional treatment of the dam. Obviously, development of an avian embryo within an egg precludes manipulation of the maternal environment.

Postnatal skeletal muscle growth involves two general biological processes: DNA accumulation and protein accretion. The size of skeletal muscle is directly proportional to muscle DNA content. In chickens, 94-99% of total muscle DNA accumulates postnatally, while 50-88% of total muscle DNA accumulates postnatally in mammals (Allen et al., 1979). Variation in amount of muscle DNA accumulated postnatally is likely due to species differences, as well as the time of initial sampling. Satellite cells are the only known source of nuclei contributed to growing skeletal muscle. Satellite cells have been isolated from mammals and birds, and unique culture conditions have been described for several species (Dodson et al., 1996). Satellite cells from avian and mammalian species respond in a similar fashion to many growth factor and hormonal stimuli. However, avian satellite cells express growth hormone receptors and proliferate in response to exogenous growth hormone, yet mammalian satellite cells do not respond to growth hormone. In addition, epidermal growth factor stimulates proliferation of satellite cells in some mammalian species, but has no effect on avian myoblasts or satellite cells. Avian species possess only one type of insulin-like growth factor (IGF) receptor (Type 1), while mammals have both Type I and Type II IGF receptors. The functional significance of these differences between mammalian and avian species is being investigated.

Skeletal muscle protein accumulation occurs when protein synthesis exceeds degradation. In all species, fractional protein synthesis and degradation rates are high in young animals and decline in older animals. Fractional accretion of muscle protein also decreases with age. Rapidly growing chickens and turkeys generally have higher fractional rates of protein synthesis, degradation, and accretion than mammalian livestock species. Poultry breast muscles also have higher rates of accretion than leg muscles. Species differences in muscle growth characteristics and muscle differences within species may reflect differences in muscle fiber type.

Virtually all muscles are composed of mixtures of fiber types and may be classified as red or white based on the relative proportions of fiber types present. Poultry breast muscles typically have a higher proportion of fast-twitch, glycolytic (white) fibers than muscles of mammalian species. Differences in fiber type can influence growth rate and postmortem characteristics such as onset of rigor mortis, pH decline, color, water-holding capacity, and tenderness. The rate of rigor onset is very different for avian and mammalian species and has a large influence on how the meat is handled during processing. Broiler muscle undergoes rigor development at a very

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*D.M. Smith and M.E. Doumit
Department of Food Science and Human Nutrition
Michigan State University, East Lansing, MI 48824
smithde@pilot.msu.edu

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rapid rate and is usually sufficiently tender within 4 to 6 hours after slaughter. In contrast, rigor onset in beef occurs between 6 and 12 hours postmortem, and beef are typically aged at least 14 days to optimize tenderness. Handling of poultry and livestock at slaughter is very important. Rough handling and pre-slaughter stress may lead to bruising, broken bones, blood splash, dark cutting, or more rapid pH decline leading to pale, soft, and exudative meat.

Although the pH of all muscles decline after slaughter, the ultimate pH varies among species and within muscles of a single species. Poultry has an ultimate pH of 6.0 to 6.5, whereas beef muscle pH ranges from about 6.0 to 5.5. Within a species, white muscles have a lower ultimate pH than red muscles. For example, turkey breast and thigh meat have ultimate pHs of 6.0 and 6.4, respectively. Muscle pH has a large influence on product quality as it affects water-holding and textural properties of the products due to the influence of pH on protein solubility and functionality.

All meats provide important nutritional contributions to the human diet. Meat is an excellent source of protein, vitamins, minerals, and essential fatty acids. One of the major differences between beef, pork, and poultry is the amount, location, and composition of fat. The easiest way to reduce the fat content of poultry is to remove the skin, abdominal fat (fat pad), and subcutaneous fat by trimming. Poultry meat has very little marbling or intramuscular fat, thus carefully trimmed breast meat may contain only 1% fat. On the other hand, beef and pork have more intramuscular fat, so even closely trimmed beef and pork have higher fat contents than poultry. In both avian and mammalian species, fat has been an important component in grading and marketing systems. These systems continue to hinder the production and marketing of leaner animals.

Fat imparts important flavor notes to meat and plays an important role in consumer desirability. Water extractable components are responsible for a “generic” meaty flavor, whereas lipids are responsible for the characteristic flavor profile of each species. Modifications in low-fat meat formulations are often required to obtain desirable flavor properties. A bland flavor is especially problematic in many low-fat poultry products. Spices, natural flavors, and other meats (beef and/or pork) are often added to poultry franks to improve flavor.

Another major difference between species in is the fatty acid composition of the lipids. Beef muscle has the highest concentration of saturated fatty acids, whereas poultry is highest in unsaturated fatty acids. Beef, pork, and poultry fat are comprised of about 49%, 38%, and 32% saturated fatty acids, respectively (USDA, 1998). Nutritionists are recommending that adults reduce their consumption of saturated fat to less than 10% of energy intake due to the relationship between consumption of saturated fat and cardiovascular disease (USDA, 1995).

Although consumption of foods high in polyunsaturated fat is considered desirable and is one reason for the increased consumption of poultry in the US, poultry meat is more susceptible to lipid oxidation than beef or pork. Polyunsaturated fatty acids are more susceptible to oxidation than saturated fatty acids because of the reactive methylene carbon in the 1,4 pentadiene structure formed by the double bonds. Control of oxidized or warmed-over flavor is a major problem in pre-cooked and frozen meats commonly used in convenience foods. Lipid oxidation often occurs at a faster rate in red meat due to higher fat and myoglobin contents when compared to white meat of the same species.

Fat from different species has different melting points, also due to the differences in the fatty acids. Careful temperature control is important to prevent smearing of the raw meat batters during chopping and to minimize fat loss during cooking. This has led to different recommendations for chopping temperatures and cooking schedules when preparing comminuted products.

Color plays an important role in consumer acceptance and purchase of all meat products. Color is a function of the concentration of muscle and blood pigments in the meat, primarily the muscle pigment, myoglobin. In general, beef contains more myoglobin than pork and poultry. A bright red color is considered essential for consumer selection of beef. Beef and pork are packaged to maximize oxymyoglobin concentration at the point of purchase by the consumer.

Large color variations occur in raw poultry muscle forcing processors to use breast and thigh meat for different products. After cooking, poultry breast meat products should be white in color. Pinking is considered a quality defect in poultry breast meat and processing conditions are chosen to prevent pink color formation. Alternatively, the low myoglobin concentration in poultry leads to color problems in cured poultry meat. Even though thigh meat is used in cured products, there is insufficient myoglobin available to react with nitrite to form an optimum cured meat color. Additives such as oleoresin of paprika are often added to improve the color of cured poultry products.

Avian and mammalian species provide excellent meat products that satisfy both the nutritional needs and sensory desires of human beings. Understanding species similarities and differences in muscle growth and processing has led to improved efficiency of production and product quality. Current and future challenges associated with efficient production of high quality products will be met by technology gained through innovative research and application of new information.

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