CONVERSION OF MUSCLE TO MEAT AND IMPROVEMENT OF EATING QUALITIES

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Introduction

Muscle is a machine translating chemical energy to physical action. At the end of this machine's working life, it becomes a valuable and nutritious food - meat. Meat includes all edible tissues of food animals slaughtered in an abattoir (licensed slaughter house) for human consumption. This includes not only skeletal muscles but also smooth muscles and organ meat (variety meat). Meat generally comes from older animals at the end of their useful period or productive life. Therefore, the eating qualities like colour, flavour, tenderness, texture, juiciness and overall acceptability get reduced. Of these, the consumers give much importance to tenderness besides the cost factor and food safety.

Meat from Zebu, the Indian cattle (Bos indicus) is inherently tough which is aggravated by age of the animals, faulty pre-slaughter care and management, slaughter techniques, processing, cooking and refrigeration. Same is the case with buffaloes, sheep and goat. The unhealthy food animals in poor condition and meat produced under unhygienic conditions deteriorate the microbiological, nutritional, toxicological and organoleptic qualities of meat. These problems in the current export and domestic market are to be solved under war footing to save the Indian meat industry from peril in the context of imposition of international food laws (Sanitary and Phytosanitory Measures and Technical Barriers to Trade) under WTO regime from 2005. Flooding of Indian market with high quality cheaper meat from developed meat exporting countries should also be foreseen seriously.

The general trend among the meat consumers, as a result of unawareness/taboos/ customs, is to cook and eat prerigor muscle or so called hot boned muscle before it is converted to meat. That is, fresh muscle with the flavour of blood serum is consumed rather than the tender, flavourful and juicy meat. Meat as a food is the product of a number of postmortem biochemical and biophysical reactions in muscle. These changes improve the organoleptic and eating qualities. Therefore, the discussion focuses on the postmortem changes in the conversion of muscle to meat, points to prevent development of toughness and to improve eating qualities.

Consequences of Death and Development of Rigor Mortis

When an animal is slaughtered, respiration and blood circulation cease and the muscles become anaerobic. Though some respiratory activity may occur on the exterior surfaces of the muscle, strict anaerobic condition prevails within deep tissues. During anaerobic glycolysis, glycogen is converted to lactic acid, which accumulates in muscle in the absence of blood circulation. This results in a pH fall from 7.2 to an ultimate pH of 5.4 after 24 h. The anaerobic glycolysis fails to maintain the level of energy supply, ATP to the muscles. On complete exhaustion of ATP or inactivation of glycolytic enzymes, rigor mortis sets in. The musculature of the carcass lives on often for many hours, until rigor mortis is established. Rigor mortis is a desirable irreversible inextensibility of muscle during when actomyosin is permanently formed leading to rigidity of muscles. Relaxation does not occur, as there is no energy. At the time of death muscle is flaccid and extensible. The fall in the pH is indispensable for the activity of the intrinsic proteolytic enzymes, which leads to proteolysis, denaturation of proteins, resolution of rigor, and improvement in tenderness and other eating qualities. Lack of glycogen yields high pH meat which tend to be dark in colour and unacceptable in appearance to the consumers at retail outlets. High pH meat is very subject to bacterial spoilage while the keeping quality of low pH meat is improved due to pH inhibition of the normal spoilage bacteria. These depend on the glycogen store in muscle preslaughter, for which animals should be well fed and well rested.

Factors affecting Glycolysis and Rigor Mortis

A number of factors, viz., level of muscle glycogen at the time of slaughter, nutrional status of animals, postmortem muscle temperature, struggling at the time of death, preslaughter stress, method of slaughter, excitement, post-slaughter handling of carcass, sex, activity of muscles, etc., can influence the time of onset of rigor mortis and glycolysis. In tropical climate rigor mortis would set in within 8-12 h. while in cold weather in 24 h. Rigor development is small at chilling (00C) and is as much as 50% at 400C. That is, on immediate cooking muscle will undergo rigor and toughening.

Abnormal Rigor and Toughening of Muscle due to faulty storage

The general practice among butchers is to debone the hot carcass (hot boning) immediately after slaughter. Hot boned prerigor (before the onset of rigor) muscle with pH above 6.8, if exposed to chill temperatures below 150C, it shortens severely - cold shortening, making the muscle tougher. This abnormal

rigor occurs in beef, mutton, chevon and turkey (muscles rich in red fibres). In pork it is less intense and insignificant in chicken. The severity of cold shortening and toughness increases with the physiological age of the animal.

When frozen, cold shortened, prerigor muscle is thawed rapidly, it shorten as much as 80% of their equilibrium length - thaw rigor. As this shortening is more powerful than the other type of postmortem shortening, muscles become very tough. About 35% of the muscle weight can be lost by loss of fluid by drip. Therefore, hot boned, prerigor muscle on chilling or cooking immediately after its purchase by consumer or by meat packer or processor will lead to toughening, which is presently being confronted by them.

These problems can be solved by:

1. Electrical stimulation of carcasses within 30 min. of exsanguination.
2. Holding carcasses at 180C till the onset of the rigor mortis and subsequent chilling.
3. Hanging the carcass by obturator foramen in the pelvic bone rather than the conventional hind leg suspension by Achilles tendon (tender stretch method).

Postmortem Conditioning or Ageing

Although rigor mortis is the most pronounced change that muscle undergoes, other changes also take place, which is known as ageing. Holding unprocessed muscle or carcasses for various lengths of time at chilling temperatures (0-40C) without microbial spoilage, during when a series if biochemical and biophysical changes take place which improve the tenderness, colour and juciness of meat and convert muscle to meat. This is known as conditioning or ageing (resolution of rigor). Rigor muscle slowly relaxes and after 2 to 4 days at chill temperatures it becomes flaccid and meat becomes tender.

The tenderizing effect of ageing are due to endogenous proteases in the muscle, viz., cathepsins, and beta glucuronidase from lysosomes, calpains in the sarcoplasm, alkaline protease, muscle alkaline protease and serine protease. Lowering of pH below 6.8 increases the permeability of lysosomal membrane leading to leaching out of the enzyme. Lowered pH is required for these enzymes' optimum activity. They act on myofibrillar proteins. The products of proteolysis -the dipeptides- impart the characteristic flavour to aged meat and also increase the water holding capacity (juciness). . This is how fresh muscle is converted into meat by conditioning. After electrical stimulation, muscles become tender on ageing for only 2 days.

In high temperature conditioning, carcasses are held at 150C or higher. This can be applied to prerigor carcasses. That is, at 160C for 10 h. the tenderness increased compared to holding at 00 to 10C. In high temperature ageing, collagen is also lysed by lysosomal enzymes. This type of conditioning improves meat tenderness by reducing cold shortening.

Meat Tenderness

The texture and tenderness of meat depends on two factors:

1) the amount and properties of collagen of the muscle connective tissue (background toughness) and
2) the state of the contractile proteins - actin and myosin (processing toughness)

The cross links of collagen fibres in younger animals are thermolabile and so readily ruptured during cooking. In older animals thermostable cross links predominate giving toughness to cooked meat. Locomotory muscles have more collagen fibres than in supporting muscles. Only on moist cooking above 600C collagen can be converted into the digestible gelatin. Therefore, meat from limbs are to be stewed rather than fried. Cold shortening and thaw rigor can be avoided by adjusting the chilling regime.

High temperature ageing, electrical stimulation, calcium chloride marination, enzyme treatment, tender stretch and hydrodyne method using high velocity shock waves in jackets can tenderize meat.

Conclusion

The major cause of toughness in cooked meat is the rapid chilling of prerigor muscle. Animal maturity has also a role in toughness. Tenderness can be increased by the ageing of rigor muscle and by preventing cold shortening and thaw rigor. Muscle after postmortem changes is meat which is tender, juicy, flavourful and with 'bloom', the appealing cherry red colour of uncooked aged meat. The volatile products of proteolysis during ageing impart the characteristic flavour to each meat besides increased juciness.