CONVERSION OF MUSCLE INTO MEAT

4TH YEAR VETERINARY STUDENTS

CONVERSION OF MUSCLE INTO MEAT

Homeostasis

- All organs and systems in a living state operate to maintain an internal environment under which they can perform their functions efficiently
- This is within a narrow range of pH, temperature, oxygen conc., and energy supply
- Maintenance of this balanced internal environment- homeostsis

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- Homeostatic mechanism is presided over by nervous and hormonal control that allow adjustments

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- Meat is the result of biochemical and biophysical changes initiated in muscle after death of animal – post mortem aspect of muscle
- Pre-slaughter handling could result in significant changes – bruising can be measured by assessing the concentration of creative phosphokinase and aspartate transaminase

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- Moisture loss is a consequence of fatigue or hunger in the immediate pre-slaughter period. This is marked in pigs.
- Fasting of animals during transportation results in weight loss more in sheep, pigs than cattle. In pigs this can be as 1kg/24hr
- Fasting or inadequate feeding in period pre-slaughter lowers glycogen reserves

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- Pigs are more susceptible to glycogen depletion after a little exercise than cattle or sheep

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Treatment	L. dorsi		Psoas	
	Glycogen (mg%)	Ultimate pH	Glycogen (mg%)	Ultimate pH
Controls (Feed &rested 14days after train travel	957	5.49	1017	5.48
Exercised 1.5hr (after train travel and 14 days fasting)	1028	5.55	508	5.55
Exercised 1.5hr immediately after train travel	628	5.72	352	6.15

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- After death - major change is circulatory failure due to stunning and bleeding.
- This initiates a complex of series of changes in muscular tissue

A). Oxygen supply fails this leads to redox potential fall.

- Respiration ceases hence glycogen cannot be broken down to carbon dioxide and water in the oxidative phosphorylation.

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- Instead substrate phosphorylation (glycolysis) with glycogen being broken down to lactic acid
- Energy rich bonds (ATP, creatine phosphate) level diminishes and lactic acid accumulates causing pH to fall
- Normal pH declines from pH 7 to 5.3 - 5.6 the ultimate pH postmortem
- With loss of ATP, membranes become permeable and Ca^{2+} are released and K+, actin and myosin bind irreversibly and rigor sets in

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- Most of proteolytic enzymes are held in lysosomes under energy gradient. With ATP loss these leak out leading to protein breakdown and exudation

B). Supply of vitamins and antioxidants ceases. This causes fat oxidation and rancidity especially in unsaturated fats

C). Nervous and hormonal regulation fails – this causes temperature to fall, fat solidifies and becomes prone to oxidation and rancidity

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D). RES fails to scavenge - stray bacteria accumulates leading to bacterial growth, spoilage and protein breakdown

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Biochemical basis of Rigor

- Rigor is akin to muscle contraction
- During muscle contraction, ATP and Ca^{++} are required. ATP causes the split of actomyosin bond leading to relaxation. Ca^{++} are required to stimulate the contractile actomyosin ATPase for myosin and Actin to combine

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- Glycogen reserves have equivalent 100mM ATP in a rested animal while Creatine Phosphate have about 40mM ATP equivalent.
- These energy reserves have capacity to maintain normal cell functions for a while after death.
- As pm changes continues ATP and creatine reserves are depleted because the re- synthetic power of the cell is lost

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- Ca^{++} is kept under energy gradient. The concentration in the cell cytoplasm is 10^{-7} mM.
- As ATP sources get depleted, Ca^{++} concentration in the cytoplasm increases to 10^{-5} mM stimulating contraction. When ATP levels fall below 4mM ATP equivalent , the actomyosin bond becomes irreversible and rigor sets in.

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Abnormal Rigor

Cold shortening

- Is a phenomenon seen in pre rigor meat if chilled to internal temperature below 15^0 C
- Cold (15^0C) stimulates release of Ca++ from sarcotubular system. This enhances the contractile actomyosin ATPase.
- Causes 30-40 fold increase in [Ca++] in the cytoplasm

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- Ca^{++} re-absorption can be efficient in a muscle with a well developed sarcotubular system. White muscles have such well developed sarcotubular system than red.
- Another source of Ca^{++} is from mitochondria system under anaerobic conditions (red muscles do not cold shorten if supplied with oxygen at $15^{o}c$). Red muscles have a higher Mitochondria concentration than white muscles

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- Combined release from sarcotubular and mitochondria with poor re-absorption potential of red muscles make them prone to cold shortening.
- Cold shortened meat is tough. If it shortens beyond 40% of original length it is tender in comparison due to nodes of super contraction that are weak points due to buckling of myosin at Z lines

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- Prevention - cooling meat swiftly to 15^{o}C and maintaining it until rigor sets in at this temperature.
- Posture of hanging achilles tendon versus pelvic changes the muscles that are prone to cold shortening – this not practical
- Electrical stimulation immediately after death with 3000 volts AC or 210 volts DC accelerates PM glycolysis and pH fall.

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- Electrical stimulation shortens the time for rigor – accelerating glycolysis pre and post stimulation

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Thaw rigor,

- Is a severe form of contraction that occurs when meat frozen pre-rigor is thawed
- Contraction produces shortening to 80% of original length
- Accompanied by release of drip that results in severe toughening of meat

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Dark cutting Beef (DCB)

- This is an abnormal rigor seen in beef animals that have been severely stressed either starved.
- The glycogen reserves are depleted before slaughter, the ultimate pH des not fall to 5.3-5.6. It remains high, 6.8.
- The pH is above IP of proteins, the IFS is high and protein has a net negative charge

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- Leads to high water holding capacity.
- High WHC leads to high residual activity of cytochrome enzymes
- The above WHC and actvity of cytochrome presents a barrier to diffusion of O_2– layer of O_2Mb is small and purplish- red color of myoglobin predominates. Meat appears dark hence dark cutting beef or glazy bacon

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Pale soft exudative muscle (PSE)

- Is a condition seen in pigs that have been selected for high FCE and leanness such as pietrains and Danish Landrace. This has also selects for pigs that have excess growth hormone (GSH)and deficiency in adrenocorticotrophic hormone(ACTH)

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- On exposure to stress like transport, these pigs sets in motion fast glycolysis with low pH while body temperature is high.
- This denatures sarcoplasmic proteins which precipitate on myofibrils giving a cooked appearance
- Denatured proteins are poor in holding water therefore there is exudation

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- Significance - difficult to cure and rejected by consumers

REVISION

- What is homeostasis?
- Describe the effects of circulatory failure in muscle post mortem
- Compare and contrast Cold shortening and thaw rigor and DCB and PSE.
- What is the biochemical basis of rigor?

References

- Recent advances in the chemistry of meat by Bailey A.J
- Meat Science 5th R.A. Lawrie
- The Science of meat and Meat products – Sweiggert et al
- Muscle Physiology by Briskey