Basic Meat Science Principles

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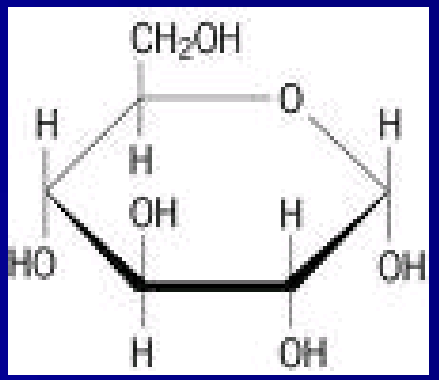
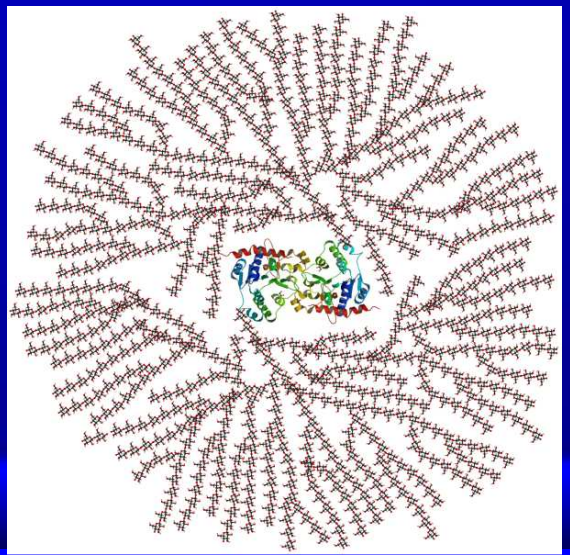
Overview

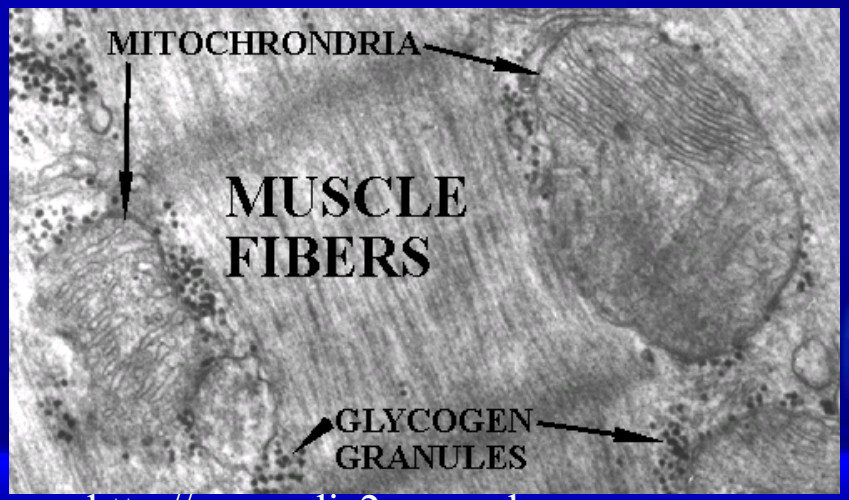
- Muscle energy
- Conversion of muscle to meat
- Decrease of pH
  - Associated quality
  - Water holding capacity
- Proteins
  - Types in meat
  - Functionality

Muscle Energy



- Glycogen
  - Primary energy source
  - Grouping of glucose (dextrose) molecules
  - Stored in muscle – as large granules
  - Used locally
  - Excess amounts will be stored as fat





http://www.slic2.wsu.edu

Converting Glycogen to Energy

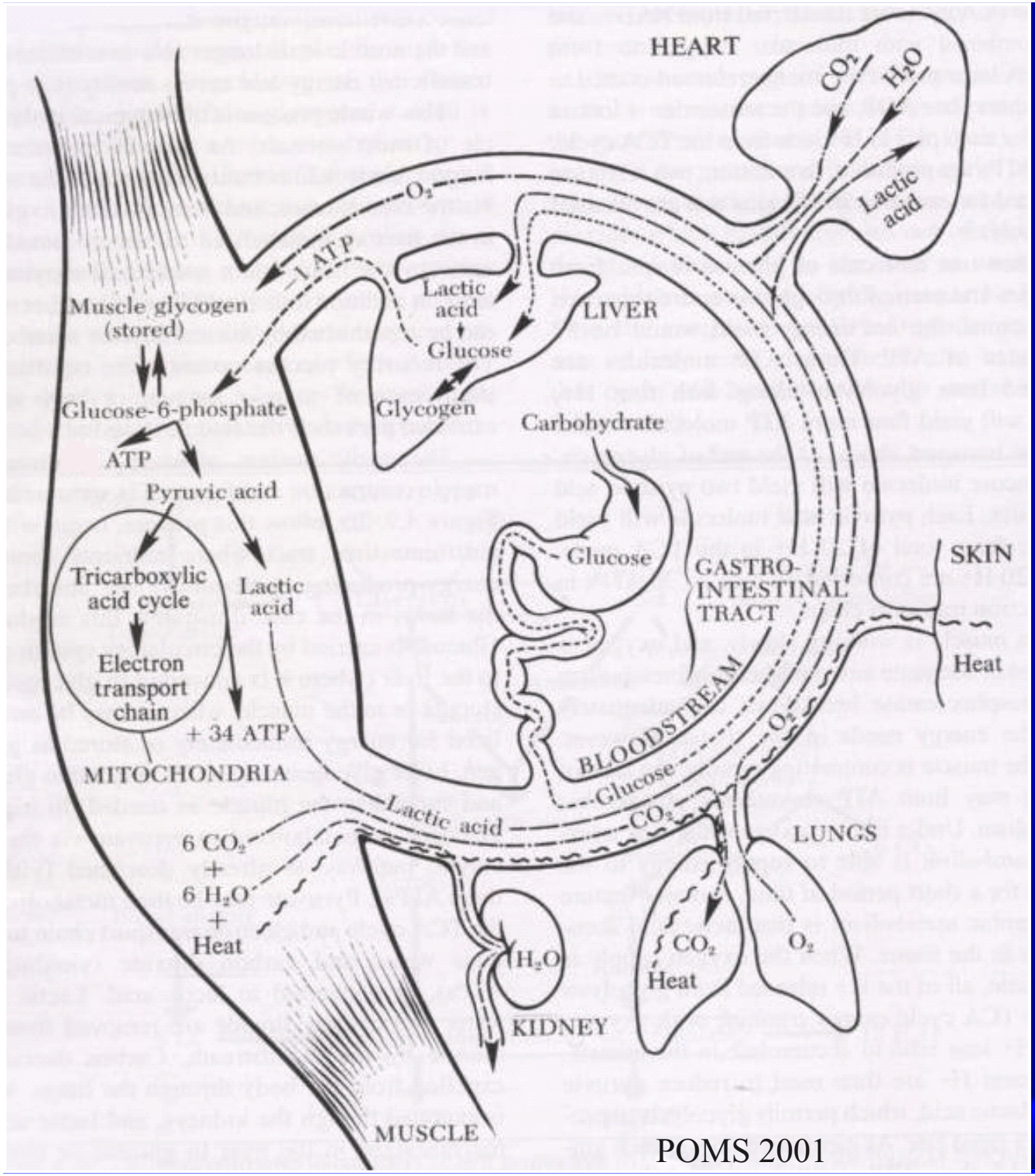
- Aerobic – with oxygen available
  - 1 glucose can provide lots of energy
  - Byproducts include H_2O, CO_2, and heat
    - Expelled as waste
  - Type of energy – think marathon runner
    - Requires lots of energy
    - Long period of time or endurance

Converting Glycogen to Energy

- Anaerobic – when oxygen is limited
  - 1 glucose can be broken down quickly
  - Only provides 1/18th the energy of aerobic
- Byproduct is Lactic Acid
  - Waste must be removed by blood stream
  - Taken through heart or to liver where it is repackaged to glucose
- Type of energy – think weight lifter
  - Quick burst of energy, strong response for short period of time

What happens at Slaughter?

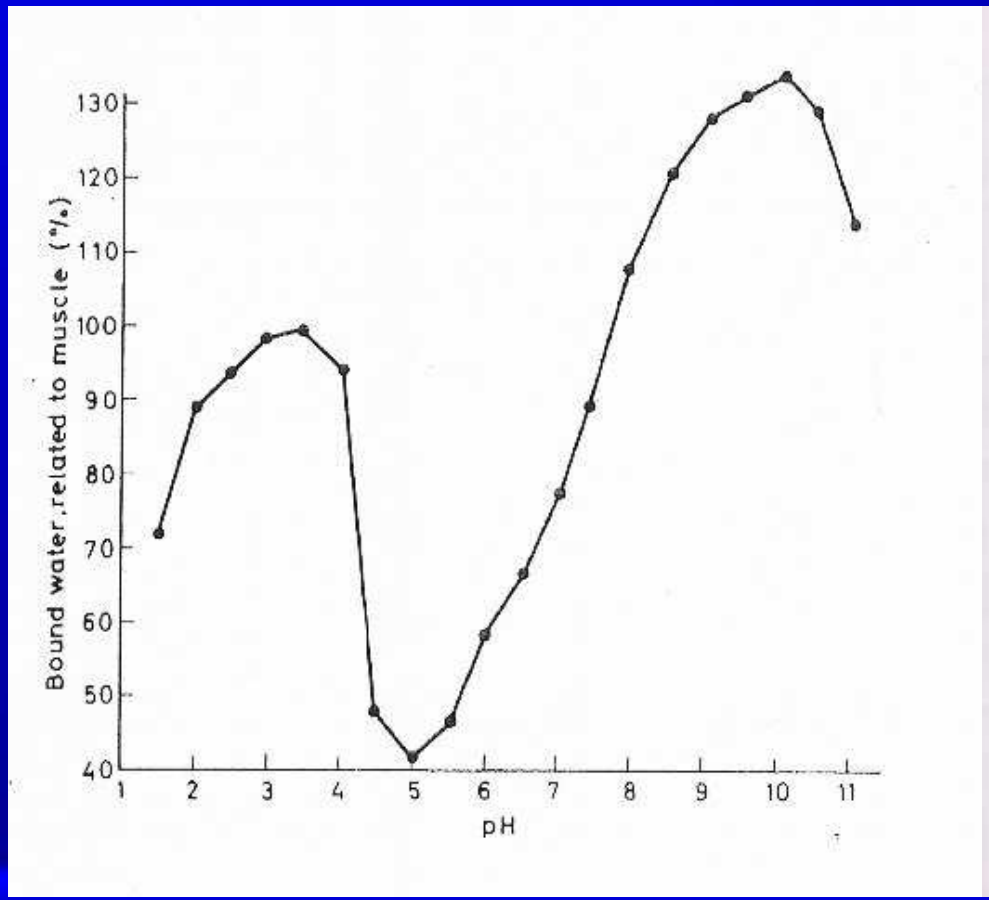
- O_2 is quickly used up
- Carcass tries to maintain life processes
- Switches to Anaerobic production
  - Part of maintaining homeostasis is using energy available to keep processes going
  - Builds up Lactic Acid
    - Can't remove – No blood
    - Muscle pH decreases from ~7.4 to ~5.5
    - Beef 6-12 hrs Pork 0.5-3 hrs

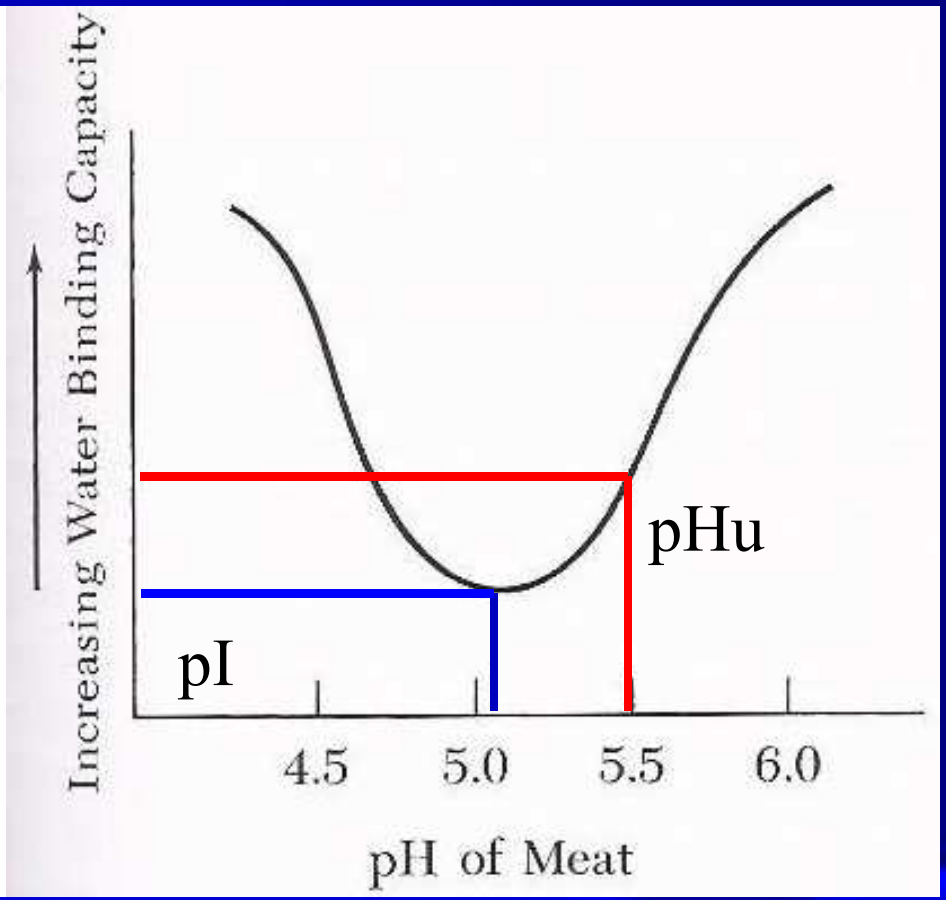


Life Processes Diagram

pH in Postmortem Muscle

- As Lactic acid builds pH will decline
  - Normally pH will move from 7.4 to 5.5





Lawrie 2006, POMS 2001

Effects of postmortem pH

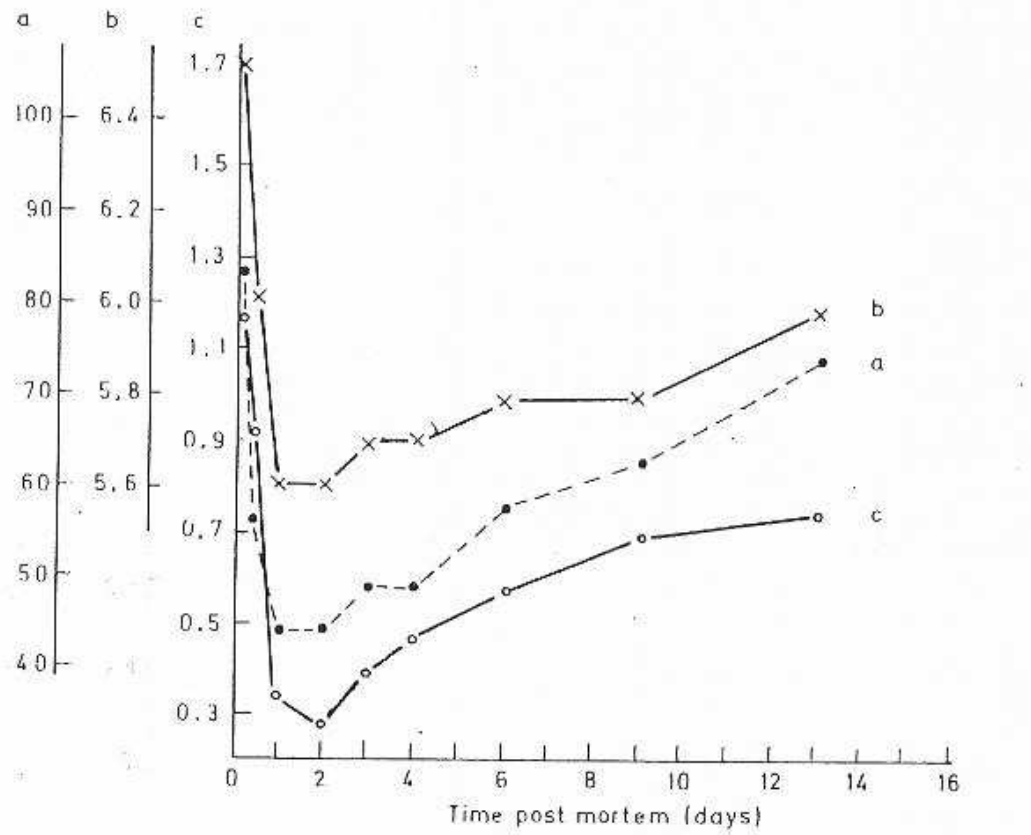


Figure 16.4 WHC: (a) % bound water, (b) pH value and (c) soluble myofibrillar protein-N of beef at different times post mortem. (From Brendl and Klein, 1970, by courtesy of Inst. Chem. Technol, Prague)

- We'll come back to this
- Keep in mind where WHC and soluble protein is at D0 compared to 1 and on

Effects of altering postmortem pH

- NaCl at pH<pI removes electrostatic repulsion
- NaCl at pH>pI causes weakening of oppositely charged ions

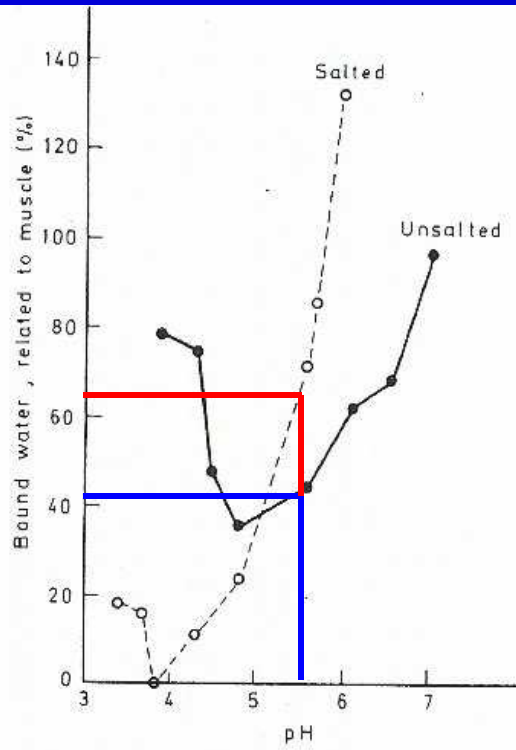


Figure 16.7 Influence of pH on the WHC of salted (2% NaCl) and unsalted ground beef (filter-paper press-method)

This effect is predominantly due to the Cl^- ion of

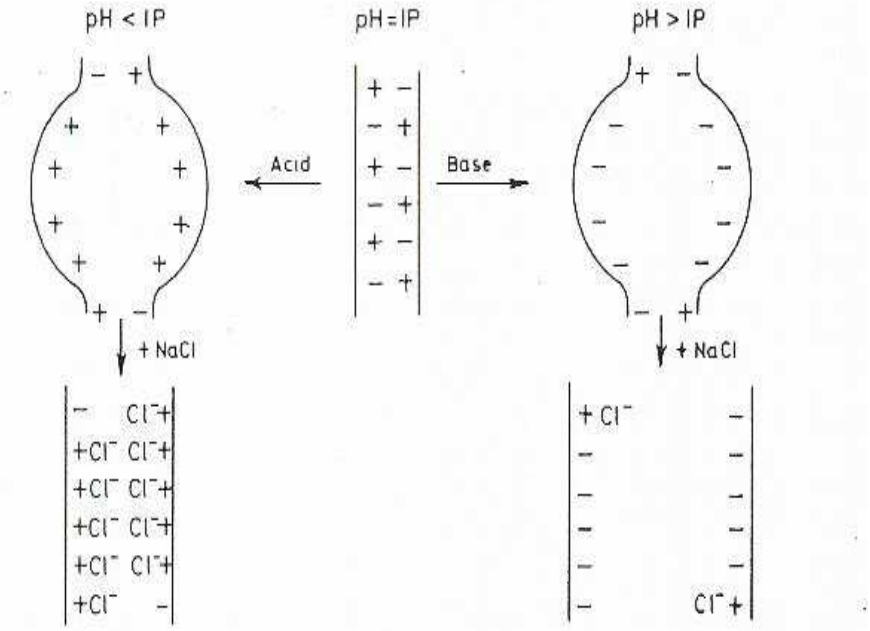
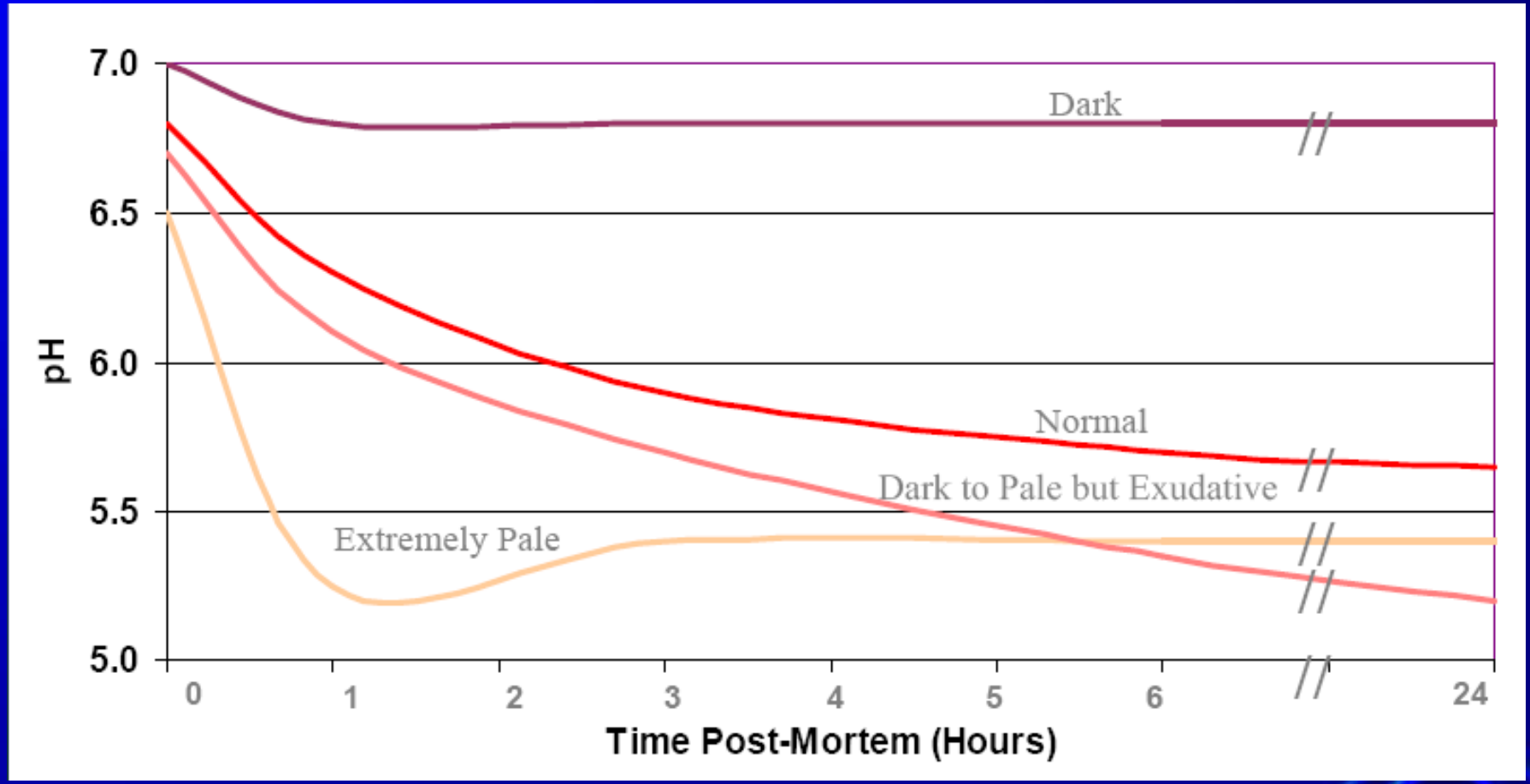


Figure 16.8 Schema of the influence of NaCl on swelling or WHC of meat at pH values above and below the isoelectric point

Stress on Meat pH and color/WHC



Adapted from Briskey et al., 1964

Effects of short-term stress

- Beef – not much of an effect
  - Fairly resilient to short-term stressors
  - Could lead to premature browning
    - Largest concern for ground beef
    - Typically not an issue for further processed beef products

Effects of short-term stress

- Pork – susceptible to short-term excitement
  - Causes Pale, Soft and Exudative meat (PSE)
  - Glycogen gets converted to Lactic acid
  - Can’t remove L.A. in time before slaughter
  - Postmortem pH decreases rapidly
  - Proteins get denatured
    - Increased heat production + low pH

Results of PSE Pork

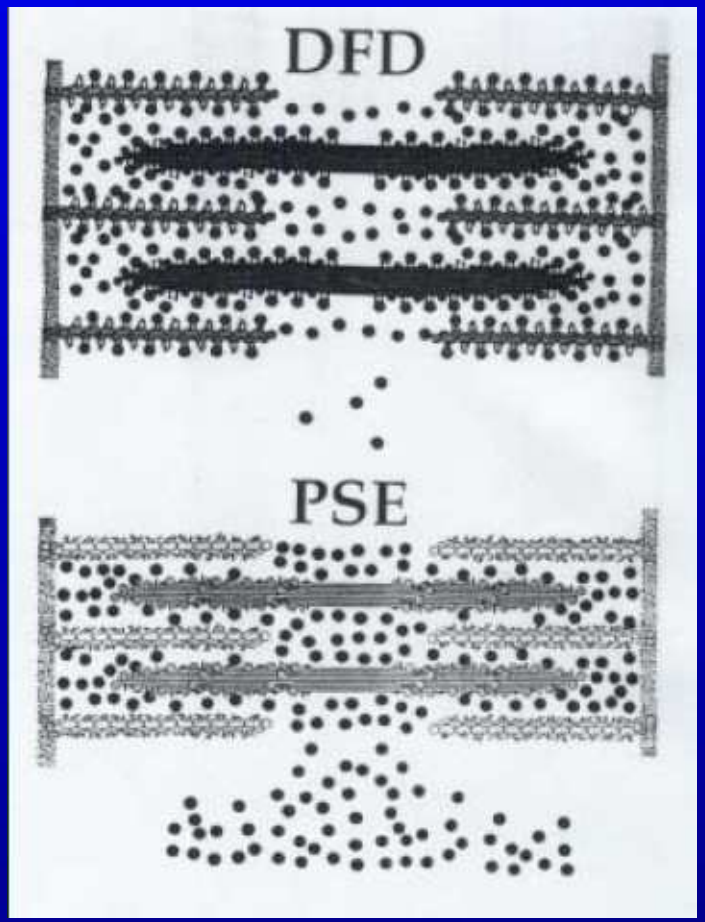
- Denatured proteins are open and can't bind water
  - Muscle weeps or exudates
  - Light reflection causes pale look
  - May influence ionic strength during processing

Effects of long-term stress

- Beef and pork are susceptible
  - Glycogen is used for prolonged energy consumption
  - Usually no new inputs (feed)
  - At slaughter there is no glycogen and therefore no L.A. to decrease pH
  - No acid, pH>pI and protein structure stays open allowing for stronger water binding

Effects of long-term stress

- High pH, tight water binding creates Dark, Firm and Dry meat (DFD)
  - Alters ionic strength
  - May cause persistent pinking in cooked product



Wismen-Pedersen, 1971; Kauffman et al., 1994; Doumit et al., 2003

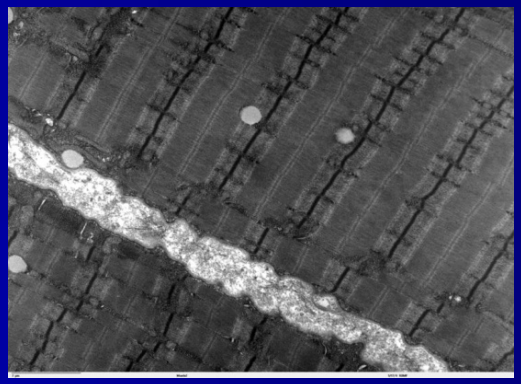
Effects of PSE and DFD on Processing

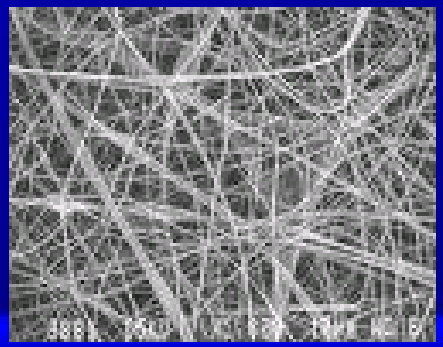
- PSE
  - Does not bind water
  - Color differences in final product
  - Shrink more than normal meat
- DFD
  - Increased microbial spoilage
  - Decreased salt uptake, protein solubility
  - Final product color differences

Meat Protein Classifications

- 3 major protein classifications

- Sarcoplasmic
  - Stromal
  - Myofibrillar

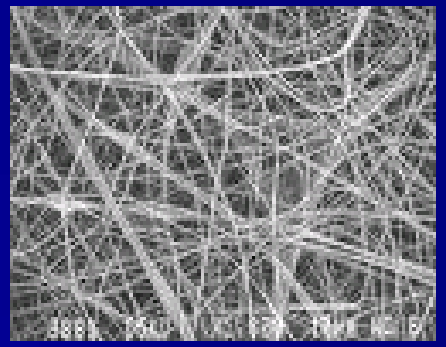




Sarcoplasmic Proteins

- Water soluble proteins - globular
  - Hemoglobin – blood at O_2 transport
    - Mostly removed from carcass
  - Myoglobin – O_2 storage in muslce
    - Gives color to meat
  - Enzymes
  - Not major contributor to direct processing
    - Specialty sausages
    - Have impact on color and possibly WHC in aged meats

Stromal Proteins



- Elastin
  - Not salt or heat soluble, Acid only
  - Found around smooth muscle
    - Digestive system, veins, reproductive
    - Heavy crosslinking
  - Shrinks upon heating
  - Low to no bind properties

Stromal Proteins

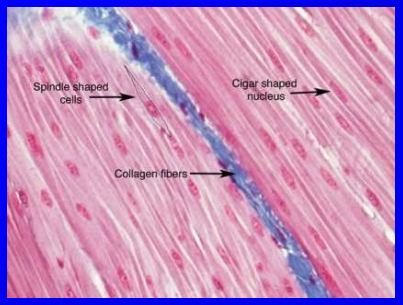
- Collagen
  - Most abundant protein in mammal tissue
  - Provides strength to system especially muscles
  - Cross-linking increases with age and muscle use
  - Locomotive muscles have increased collagen
  - Crosslinks are heat liable at ~149°F

Stromal Proteins

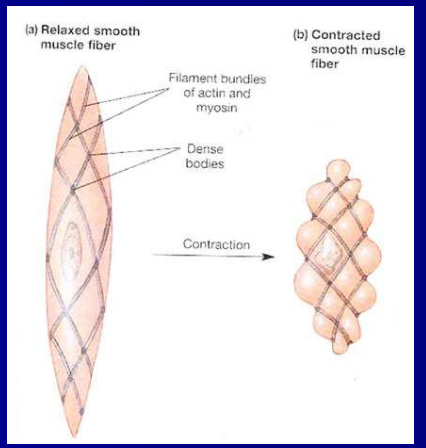
- Collagen
  - As crosslinking increase, solubility decreases
  - Heat turns collagen to gelatin
  - Gelatin gives certain products texture and can increase moisture (loaves, pâté)
  - Non-liable collagen shrinks during heating
    - Forces moisture out
    - Cause fatting out in emulsions
    - Low bind properties

Myofibrillar Proteins

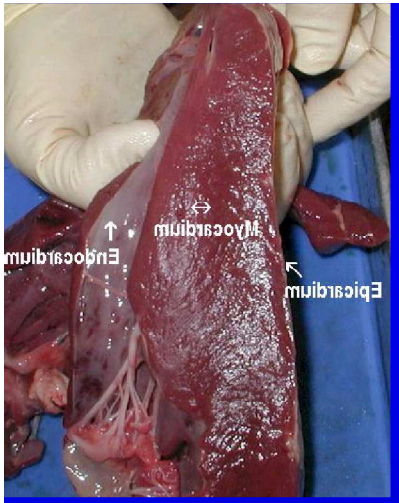
- Salt soluble (high ionic strength)
  - Calcium or Potassium salts
  - Value to meat processing
- Associated with muscle fibers
  - A – Smooth, B – Cardiac, and C – Skeletal
- Major proteins
  - Myosin, Actin



Myofibrillar Proteins



- Smooth Muscle
  - Largely involuntary
    - Digestive, reproductive, blood system
  - Usually have elastin to provide support and elasticity
  - Variety meat category, typically limited in processed meat production
  - Low binding ability



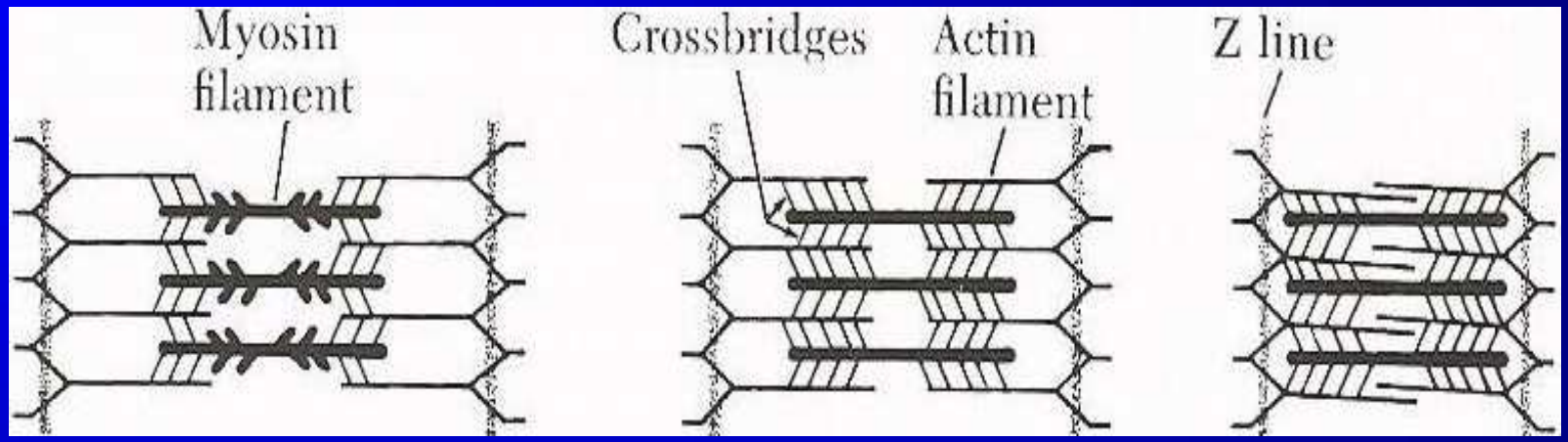
Myofibrillar Proteins

- Cardiac Muscle
  - Very specialized
  - Low quantity per animal
  - Protein structure like skeletal muscle
  - Intermediate to low bind ability
    - Heavy connective tissue content due to amount of work required

Myofibrillar Proteins

- Skeletal Tissue
  - Most important for processing
  - Proteins Actin and Myosin are most abundant
    - Proteins responsible for contraction
  - Actin and Myosin are Salt Soluble Heat Coagulable (SSHC) proteins

Myofibrillar Proteins

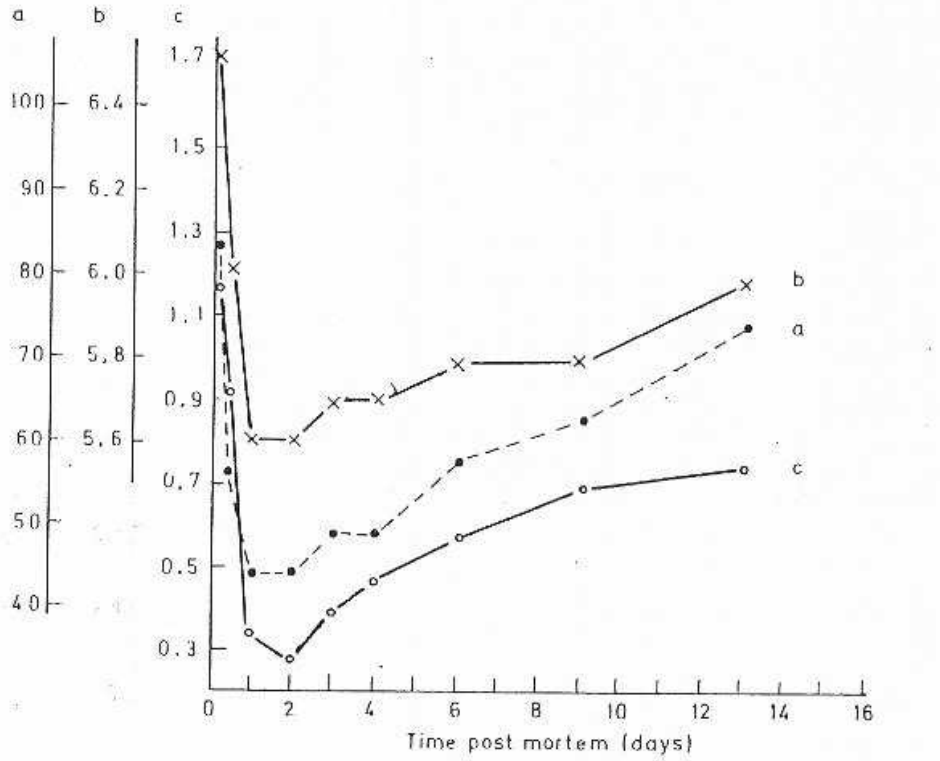


- During contraction or rigor actin and myosin bonds
- Force is exerted pulling fiber together
- Tighter bond, more force = less space for water, and decreased WHC

Skeletal Muscle

- Adding salt will extract proteins and cause them to unfold
  - Creates binding sites for water
  - Acts as “glue” for restructured products
- As time postmortem increases proteins are degraded by enzymes
  - Solubility and WHC decreases then slowly increases

WHC and Solubility over time



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Skeletal Muscle Fiber Types

- White fibers
  - Thicker, more connective tissue, more glycogen
  - pH may decrease more, creating more heat
  - May see more protein denaturation

Skeletal Muscle Fiber Types

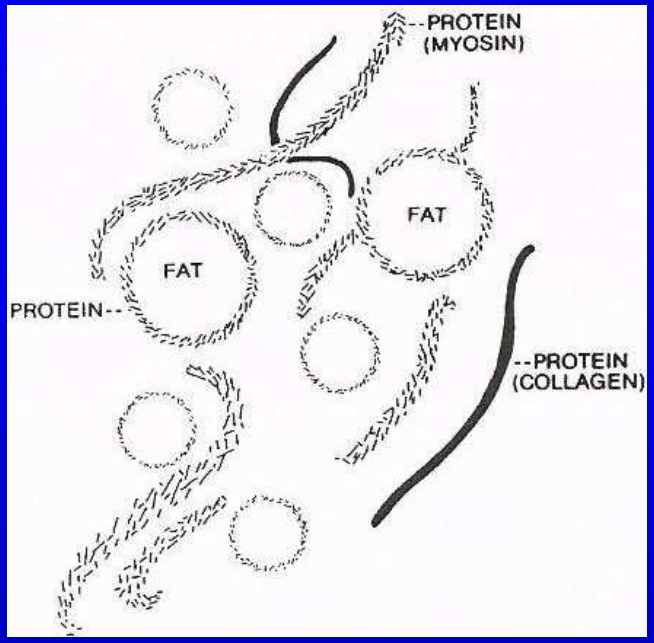
- Red Fibers
  - Increased myoglobin
  - Typically thinner
  - Less connective tissue

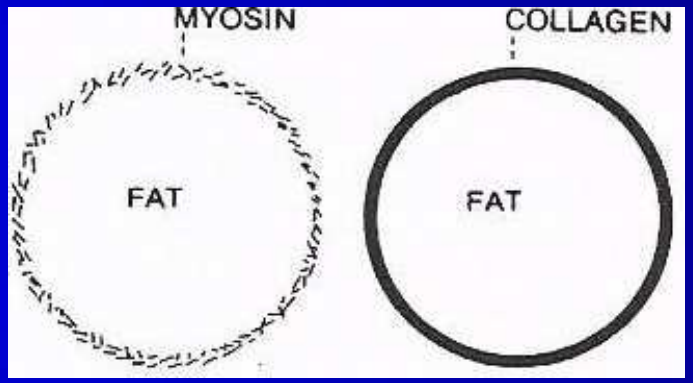
- Muscles are a combination of white and red fibers
- Use will determine which is predominant

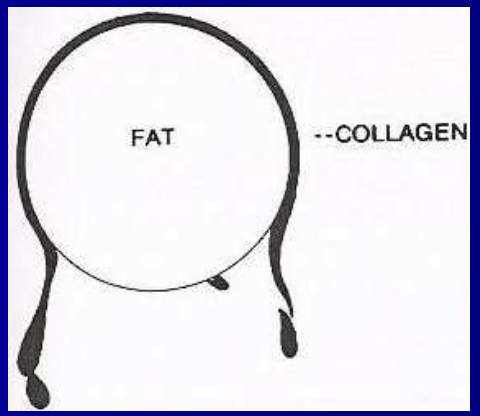
How Proteins React to Processing

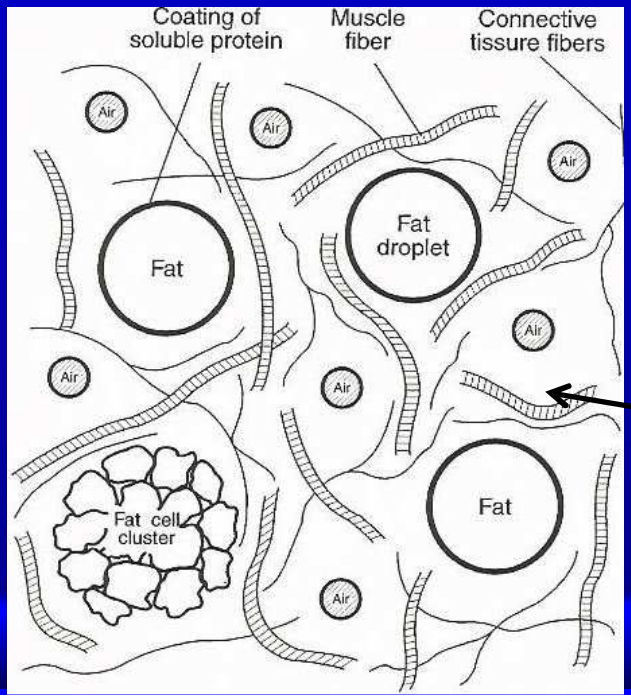
- All factors can influence how the proteins chosen will impact final product
- If using least cost formulation considerations should be made
  - Muscle type, protein type, ionic strength, PSE, DFD, fat level ect
  - Slight formula adjustments may be required
- Pre-blending and/or hot-boning may aid in consistency of final product

Proteins in Emulsifications









Spices will also
be intermixed
in the matrix

Hot Boning/Processing

- Pulling muscle prior to rigor formation
  - Usually add salt and grind
  - Exposes muscle to O_2
    - Energy is used aerobically, little lactic acid production to decrease pH
    - Higher pH increases WHC

Hot Boning/Processing

- Pre-rigor grinding
  - Disrupts actin and myosin
  - Keeps them from bonding
  - Increases space within the muscle for water
- Addition of salt
  - Solublize protein at optimal point
  - Unfold for increased WHC
  - Salt interferes with rigor process

Binding Values of Various Meats

- Will vary depending on source
  - High fat and High connective tissue will be lower

High	Intermediate	Low	Filler
Bull Meat	Beef head/cheek	Hanging Tender	Ox Lips
Cow Meat	Pork head/cheek	Weasand Meat	Tripe
Beef Chuck	Beef Flank/Plate	Giblets	Pork Stomachs
Pork Shoulder	Beef Navel	Tongue Trimming	Skins
Lean Pork	Beef Shank	Poultry Backs	Snouts
Skinless Poultry	Pork 50's	Skin on Poultry	Lips
Beef 90's	Pork Jowl	Defatted Tissues	Livers
Veal 90's	Beef Brisket		Spleen
	Heart – Beef/Pork		

Other Binding Values

Pork

Ingredients, pork	Fat level (%)	Color[a]	Bind[b]
Bacon ends	70	0.10	0.05
Backfat, untrimmed	80	0.20	0.30
Backfat, trimmings	62	0.25	0.15
Belly, trimmings	70	0.20	0.30
Blade meat	8	0.80	0.95
Cheek meat, trimmed	15	0.65	0.75
Ears	10	0.10	0.20
Ham, boneless	19	0.60	0.80
Head meat	25	0.50	0.80
Hearts	17	0.85	0.30
Jaw meat	8	0.80	0.80
Jowls, skinned	70	0.20	0.35
Lips	31	0.05	0.10
Liver	8	0.80	0.00
Neckbone, trimmings	25	0.60	0.70
Nose meat	15	0.45	0.70
Picnic, trimmings	25	0.60	0.80
Skin	32	0.05	0.20
Skirts	30	0.50	0.45
Snouts	35	0.05	010
Spleens	15	0.60	0.00
Stomachs, scalded	13	0.20	0.05
Tissue, partially defatted	35	0.15	0.20
Tongues	19	0.15	0.20
Tongue, trimmings	32	0.15	1.10
Trimmings, lean, 95%	10	0.70	0.90
Trimmings, lean, 50%	55	0.35	0.55
Trimmings, regular	60	0.30	0.35
Weasand meat	17	0.80	0.80

Beef, Veal, Mutton

Ingredients	Fat level (%)	Color[a]	Bind[b]
Beef fat	85	0.10	0.05
Bull meat	8	1.00	1.00
Cheeks	15	0.90	0.85
Chucks, boneless	10	0.85	0.85
Clods, shoulder	10	0.95	1.00
Cow meat, domestic	12	0.95	1.00
Cow meat, imported	10	0.95	1.00
Flanks, boneless	55	0.55	0.50
Head meat	25	0.60	0.85
Hearts	21	0.90	0.30
Lips	20	0.05	0.20
Liver	9	0.80	0.00
Lungs	12	0.75	0.05
Navels, boneless	52	0.65	0.55
Shank meat	12	0.90	0.80
Spleens	12	0.95	0.20
Tissue, partially defatted	25	0.30	0.25
Trimmings, lean, 85/90%	15	0.90	0.85
Trimmings, lean, 75/85%	25	0.85	0.80
Tongues	20	0.25	0.20
Tongue trimmings	40	0.15	0.15
Tripe	11	0.05	0.10
Weasand meat	6	0.75	0.80
Other			
Veal, trimmings	10	0.70	0.80
Mutton, boneless	15	0.85	0.85

Various

Products	Fat (%)	Protein (%)	Moisture (%)	Binding[a]
Beef cheek meat, fresh	14.8	18.5	65.7	0.513
Beef cheek meat, two days	14.8	18.4	65.8	0.232
Beef cheek meat, frozen	14.8	18.5	65.7	0.413
Beef hearts	18.0	15.0	66.0	0.222
Beef lips	19.4	16.1	64.0	0.388
Beef skirt meat	14.0	14.0	66.0	0.389
Beef tripe	6.0	14.0	79.2	0.030
Cow beef, fresh	17.6	17.8	63.6	0.650
Cow beef, frozen	6.2	20.4	72.4	0.502
Mutton, boneless	15.2	19.0	64.8	0.405
Navels, beef	46.2	12.9	41.1	0.443
Picnic, trimmings	27.1	14.8	57.1	0.540
Picnics, rough boneless	23.4	15.6	60.0	0.488
Picnics, rough boneless, frozen	14.8	18.5	65.7	0.413
Pork cheeks, fresh	25.0	15.0	59.0	0.490
Pork cheeks, frozen	25.0	15.0	59.0	0.370
Pork blade meat	14.5	18.0	57.0	0.456
Pork, fat backs	78.0	3.2	18.8	0.276
Pork, ham scraps, S.P.	35.1	10.9	53.0	0.481
Pork, head meat	10.7	18.3	70.0	0.430
Pork hearts, fresh	22.5	16.5	61.0	0.273
Pork hearts, frozen	22.5	16.5	61.0	0.034
Pork jowls	60.6	7.5	30.8	0.355
Pork lean trimmings	26.0	16.0	57.0	0.582
Pork neckbone lean	34.0	14.5	51.0	0.485
Pork, regular trimmings	55.0	9.6	34.9	0.455
Pork, snouts	36.2	15.5	46.7	0.151
Pork, stomachs	9.4	17.8	72.0	0.020
Pork, partially defatted chopped	33.0	14.7	51.3	0.268
Pork, partially defatted fatty tissue	26.0	17.4	55.0	0.079