



Meat

Main components of meat

A. Muscle tissue: It is the most abundant component of meat, responsible for its structure, texture, and functional properties during processing.

- **Structure of Skeletal Muscle:** Muscle → Fascicles → Muscle Fibers → Myofibrils → Myofilaments

- **Connective Sheaths:**

- **Epimysium** – covers the entire muscle
- **Perimysium** – surrounds each fascicle (bundle of fibers)
- **Endomysium** – surrounds individual muscle fibers

B. Connective tissue: It binds muscle fibers together, supports the muscle structure, and attaches muscles to bones.

- **Main components:**

- **Collagen** – main structural protein; increases toughness but converts to gelatin upon heating.
- **Elastin** – elastic and highly resistant to heat; found mainly in ligaments and tendons.
- **Reticulin** – forms fine supportive fibers in soft tissues.

C. Fat (Adipose Tissue): Mainly triglycerides containing both saturated and unsaturated fatty acids. It contributes to flavor, juiciness, tenderness, and appearance.

Types:

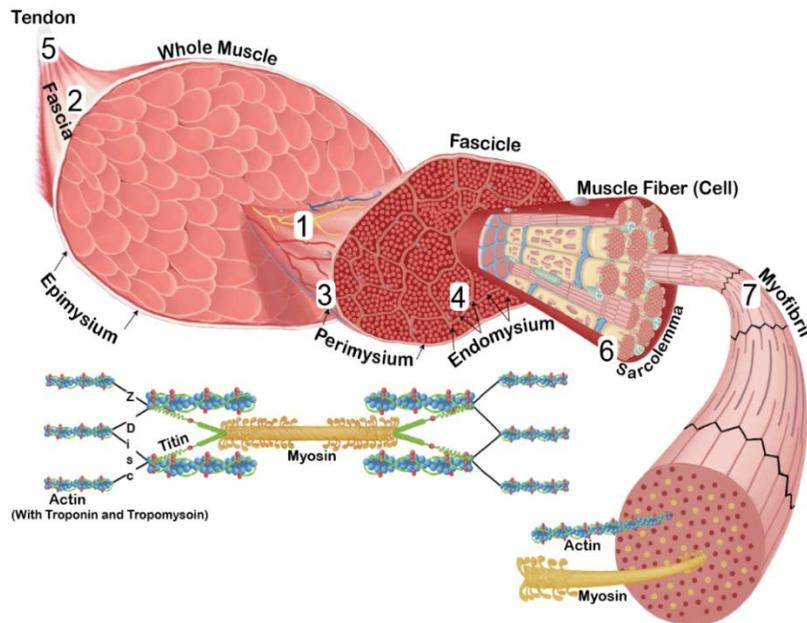
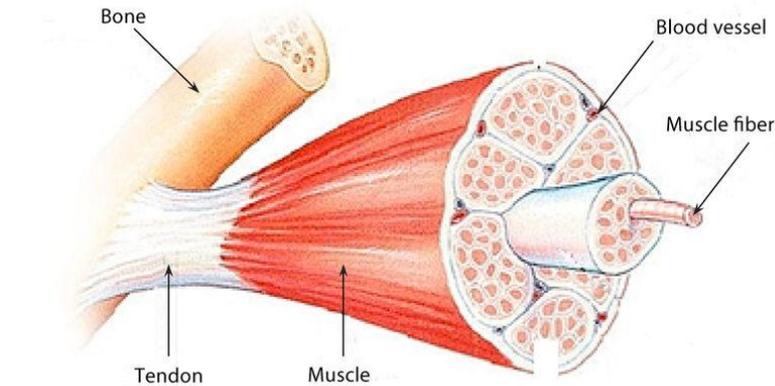
1. **Subcutaneous fat** – under the skin
2. **Intermuscular fat** – between muscles
3. **Intramuscular fat (marbling)** – within muscles; highly desirable for flavor and tenderness

D. Water : Meat contains about 65–75% water. It is distributed within muscle fibers (bound, immobilized, and free water) and influences texture, juiciness, and cooking yield (weight loss during cooking).

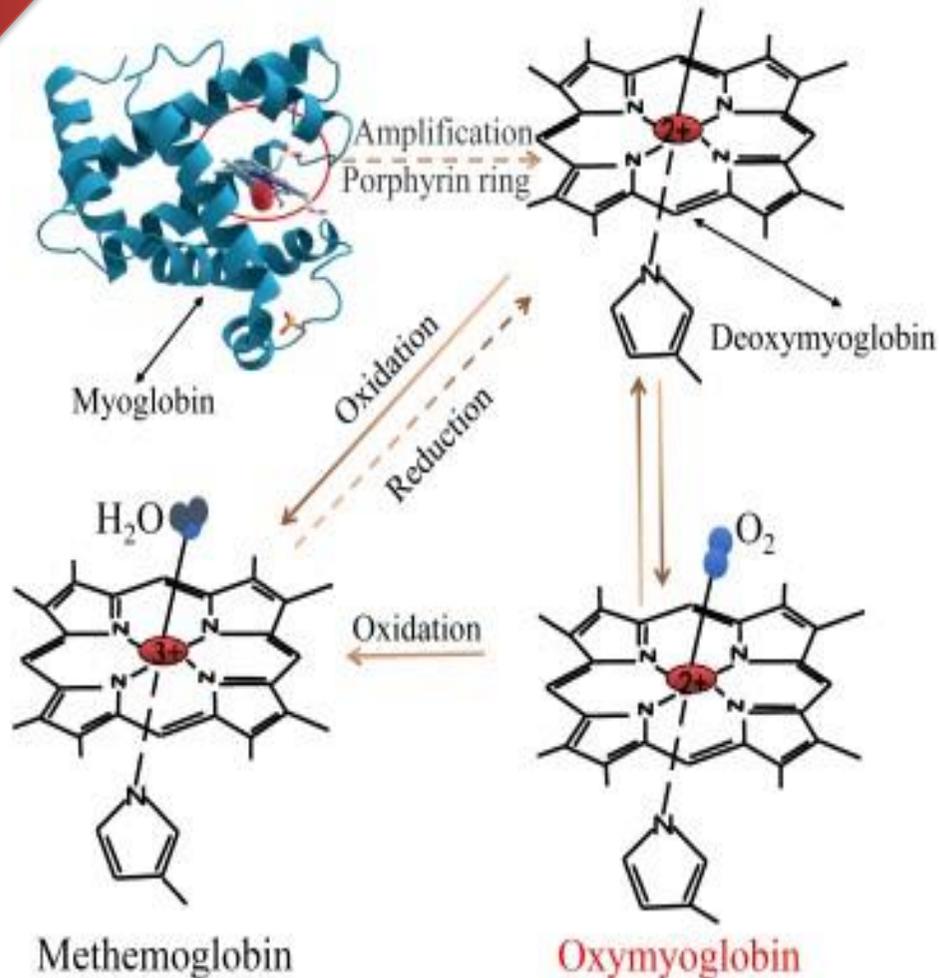
E. Minerals and Pigments

- **Myoglobin** – the main pigment responsible for meat color.
- **Key Minerals:** Iron, zinc, phosphorus, potassium, sodium, and magnesium, essential for nutrition and overall quality.

F. Nerves and blood vessels: mainly within connective tissue layers.



Myoglobin



The Three Main Forms of Myoglobin

Form	Iron state	Attached molecule	Reaction type	Color	Situation / Appearance
Deoxymyoglobin	Fe ²⁺	/	Reduced	Purplish-red	Freshly cut meat, no air exposure (vacuum packed)
Oxy-myoglobin	Fe ²⁺	O ₂	Mild oxidation	Bright red	Meat exposed to air, typical "fresh meat" color
Metmyoglobin	Fe ³⁺	H ₂ O or OH ⁻	Oxidized	Brownish	Aged or poorly stored meat (discoloration)

- **Myoglobin** is the main pigment protein in muscle tissue, it consists of a globin (protein) part and a heme group, which contains an iron atom (Fe) in the center of a porphyrin ring.
- The iron atom can exist in two oxidation states:
 - **Fe²⁺ (ferrous)** → capable of binding oxygen (active form)
 - **Fe³⁺ (ferric)** → cannot bind oxygen (oxidized form)

The color of meat depends on the chemical state of this iron and on the molecule attached to it.

- **Deoxymyoglobin → Oxy-myoglobin:** Occurs when **oxygen binds** to the ferrous (Fe²⁺) iron after exposure to air.
- **Oxy-myoglobin → Metmyoglobin:** Results from **oxidation** of Fe²⁺ to Fe³⁺, leading to a **brown color**.
- **Metmyoglobin → Deoxymyoglobin:** Can occur through **reduction** by enzymatic or chemical reductants (in low-oxygen environments).

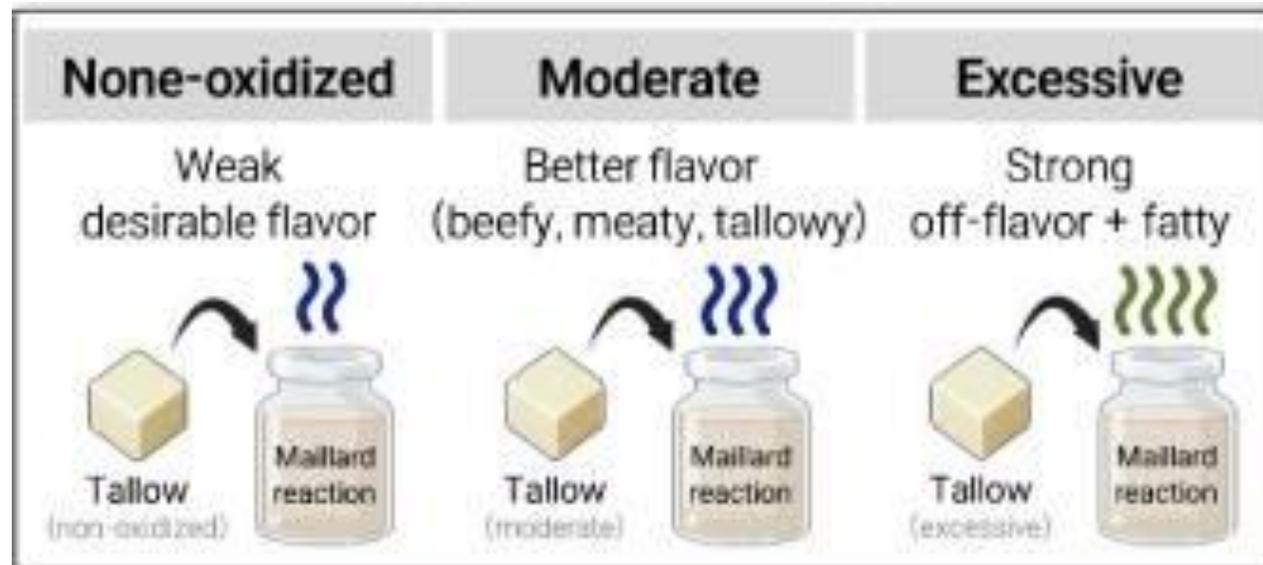
These interconversions explain **meat color changes** during storage and display:

- **Purplish-red (Deoxymyoglobin):** fresh, vacuum-packed meat.
- **Bright red (Oxy-myoglobin):** desirable "bloomed" color when exposed to air.
- **Brown (Metmyoglobin):** oxidized pigment, indicating aging or oxidation.

The degree of lipid oxidation

It impacts the flavor of cooked meat via interactions with the Maillard reaction and the state of tallow (animal fat):

- Lipid oxidation is a process where unsaturated fats react with oxygen during processing, storage, or cooking. Initially, it helps create key aroma molecules, but excessive oxidation forms unwanted aldehydes and ketones that negatively affect flavor and palatability.
- The Maillard reaction is responsible for aromatic browning; its products interact with lipids to further accentuate the meaty flavor, but only when oxidation is controlled.
- “None-oxidized”: Tallow that has not undergone oxidation produces a weak but desirable flavor. The Maillard reaction takes place, but the volatile compounds generated are limited, so the aroma is mild but pleasant.
- “Moderate”: Moderately oxidized tallow results in a better, more characteristic flavor often described as beefy, meaty, or tallowy. Here, the Maillard reaction and lipid oxidation combine to yield more intense and complex aroma compounds, which are considered optimal for cooked meat.
- “Excessive”: Excessively oxidized tallow leads to strong off-flavors and an overly fatty aroma. This stage produces undesirable volatile compounds; even with the Maillard reaction, the resulting notes are no longer favored and may mask the positive meaty flavors with rancid or



Postmortem biochemistry

ATP depletion and rigor mortis

- Loss of ATP halts muscle relaxation; actin-myosin cross-bridges lock in, causing initial rigidity. Concurrently, ionic imbalances promote water loss and changes in proteostasis.
- Molecular consequence: increased rigidity and altered sarcomere structure; subsequent proteolytic systems progressively soften tissue.

Glycolysis and pH decline

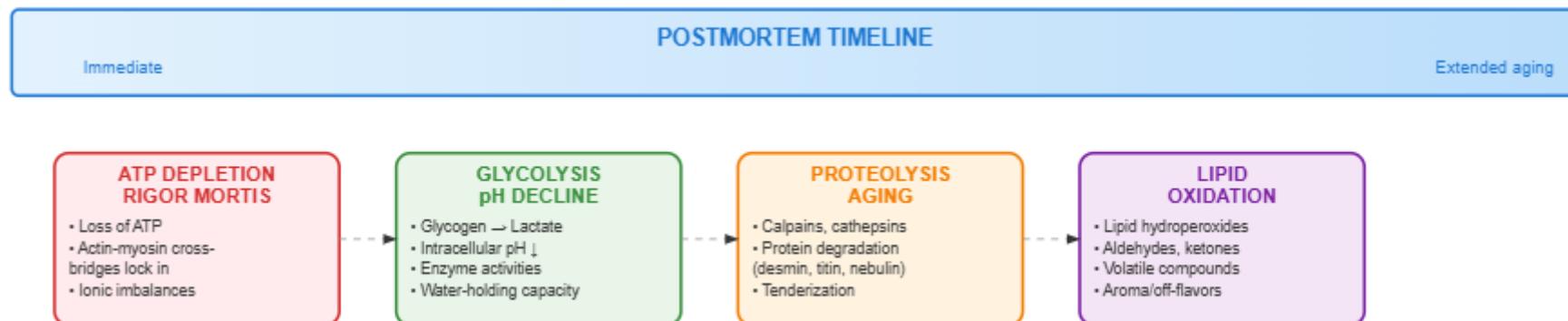
- Postmortem glycolysis converts glycogen to lactate, lowering intracellular pH (pH decline). pH influences enzyme activities (proteases, lipases), water-holding capacity, and protein charge-state.
- Molecular consequence: denaturation propensity of sarcomeric proteins, altered solubility of myofibrillar proteins, and enhanced susceptibility to proteolysis.

Proteolysis and aging

- Endogenous proteases (calpains, cathepsins) degrade key structural proteins (desmin, titin, nebulin, troponin, myosin light chains). This remodeling leads to tenderization and release of flavor precursors.
- Molecular consequence: changes in sarcomere integrity, fragmentation of cytoskeletal elements, generation of small peptides and free amino acids that contribute to taste (umami) and aroma upon cooking.

Lipid oxidation and lipid-derived volatiles

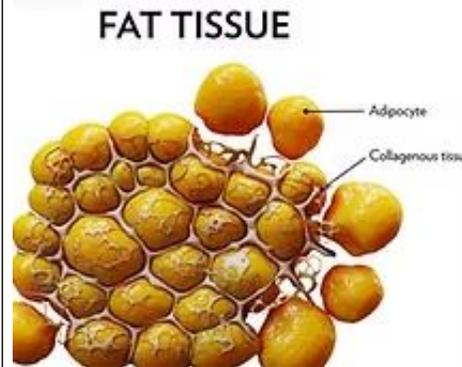
- Lipid hydroperoxides form during storage; secondary oxidation generates aldehydes, ketones, and alcohols that influence aroma and flavor, as well as potential off-flavors.
- Molecular consequence: modification of membrane integrity, potential interactions with proteins, and formation of reactive carbonyl species.



Moist vs. dry heat cooking and collagen gelatinization

Moist heat (sous-vide, braising)

- Maintains higher water activity; collagen denatures gradually into gelatin, producing tender, juicy texture; myofibrillar proteins retain some functional integrity longer due to moisture buffer.
- Molecular consequence: higher yield of gelatin in collagen-rich cuts; improved tenderness with controlled heat and time. extended cooking.



Dry heat (roasting, grilling)

Surface drying increases Maillard reactions; internal heating can over-denature proteins if not controlled; collagen gelatinization may be limited by lower water availability.

Molecular consequence: crust formation with intense aroma; potential dryness if moisture loss is excessive; collagen transformation is more surface-driven unless extended cooking.

Main industrial methods of meat product processing

1. Curing and drying

This is one of the oldest methods used for meat preservation. It involves salting and air-drying meat to reduce moisture and prevent bacterial growth. A well-known example is Gueddid, a traditional Algerian dried meat prepared from lamb or beef, seasoned with salt and spices, then dried naturally under controlled conditions.

2. Smoking

Industrial smoking units are used to give meat products distinctive flavors and longer shelf life. This method is applied to products like smoked sausages or smoked beef strips, combining traditional taste with modern hygiene standards.

3. Fermentation

Fermented meat products are produced by controlled microbial action, which develops acidity and unique flavors. Examples include dry fermented sausages, which are gaining popularity in Algerian food industries inspired by Mediterranean techniques.

4. Cooking and canning

Cooked and canned meat products are common in industrial production. These include pâtés, ready-to-eat stews, and canned meat, ensuring long preservation and convenience for consumers.

5. Grinding and emulsification

This method is widely used in the production of sausages, merguez, and meatballs. Meat is finely ground and mixed with spices, fat, and other ingredients before being cooked, smoked, or dried.

6. Freezing and vacuum packaging

Modern meat processing industries in Algeria also use freezing, vacuum sealing, and modified atmosphere packaging to preserve meat freshness, flavor, and safety during storage and transportation.



Industrial process of *Gueddid* production in Algeria

Gueddid is a traditional Algerian dried meat product, produced mainly from lamb or beef. In industrial settings, its production process combines traditional preservation methods with modern hygiene and quality control standards.

The process begins with the selection of high-quality meat cuts, usually from lean parts of the animal. The meat is then salted and seasoned with a mixture of natural spices such as cumin, paprika, garlic, and sometimes chili. The salting stage helps draw out moisture and inhibit microbial growth.

After seasoning, the meat is left to rest for several hours or days in refrigerated conditions to allow salt and spices to penetrate deeply into the tissue. Once marinated, the pieces are hung and dried in ventilated drying rooms or solar dryers, under controlled temperature and humidity. This stage replicates the traditional sun-drying process but ensures food safety and consistent quality.

During drying, the meat gradually loses most of its water content, resulting in a dense, preserved product with an intense flavor. The final *Gueddid* can be stored for long periods without refrigeration and is often rehydrated or cooked in traditional dishes such as couscous or stews.