THE UNIVERSITY OF TENNESSEE KNOXVILLE

Why do Most Foods Contain Salt?

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N EXTENSION

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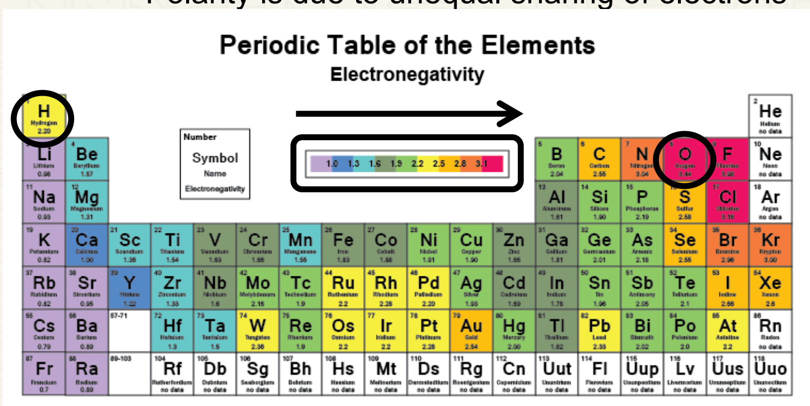
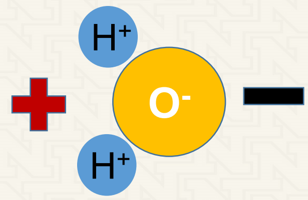
Why do most foods contain salt? It is a basic question of chemistry.

Chemistry and Salt

- Water (H_2O) is polar molecule
  - Polarity is due to unequal sharing of electrons





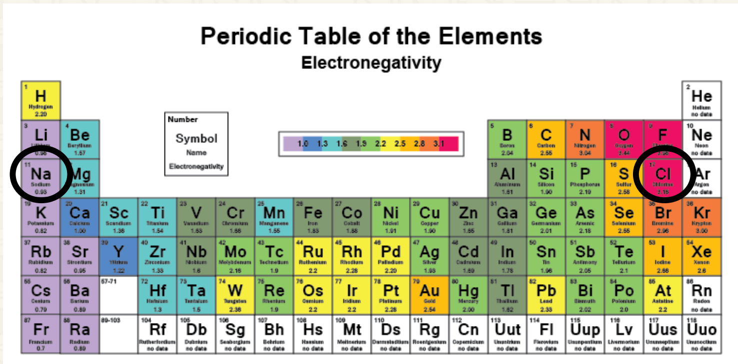
First, water is a polar molar molecule, meaning one side of the molecule has a positive charge and the other has a negative charge due to the unequal sharing of electrons.

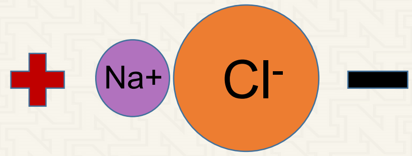
On the periodic table (CLICK), elements tend to be ordered from left to right based on electronegativity. Those elements on the left such as hydrogen (CLICK) have lower electronegativity values and struggle to hold their electrons when other, more electronegative elements, such as oxygen (CLICK) are in close proximity. These more electronegative elements that tend to be on the right side of the chart hold their electrons tight and even want to “steal” electrons from others. Hence, for water or H_2O, the oxygen molecule pulls the electrons its direction and creates a (CLICK) negative charge on the oxygen side and a (CLICK positive charge on the hydrogen side.

NEXT SLIDE

Chemistry and Salt

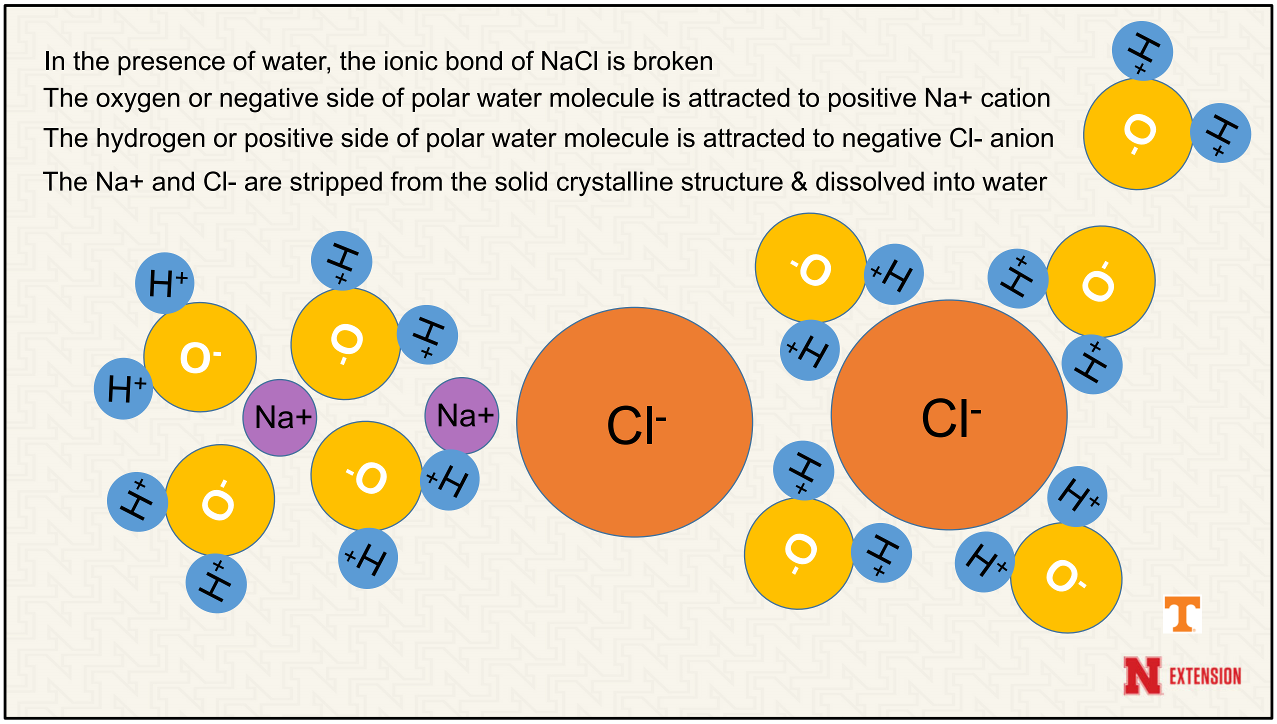
- Table Salt = NaCl





The same thing is true for salt or NaCl (CLICK) with sodium located on the left side of the periodic chart and chloride on the right (CLICK). Chloride pulls the shared electrons in its direction creating a negative charge on the chloride (CLICK) and positive charge (CLICK) on sodium.

NEXT SLIDE



How does this affect the relationship between water and salt? By itself, salt or NaCl is stable, but (CLICK) in the presence of water, the ionic bond of NaCl will be broken.

CLICK – Then, the oxygen or negative side of the polar water molecule will be attracted to the positive sodium cation.

CLICK – and the hydrogen or positive side of the polar water molecule is attracted to the negative chloride anion.

CLICK – Now, separated from one another, the sodium and chloride are stripped from the solid crystalline structure that once defined them and are dissolved into water.

NEXT SLIDE

How does this apply to meat?

- Lean meat is approximately 70% water
- The water in meat will dissolve added salt

How does this apply to meat? Well (CLICK), lean meat is approximately 70% water. Thus, the water present in meat or muscle tissue (CLICK) functions to dissolve any added salt.

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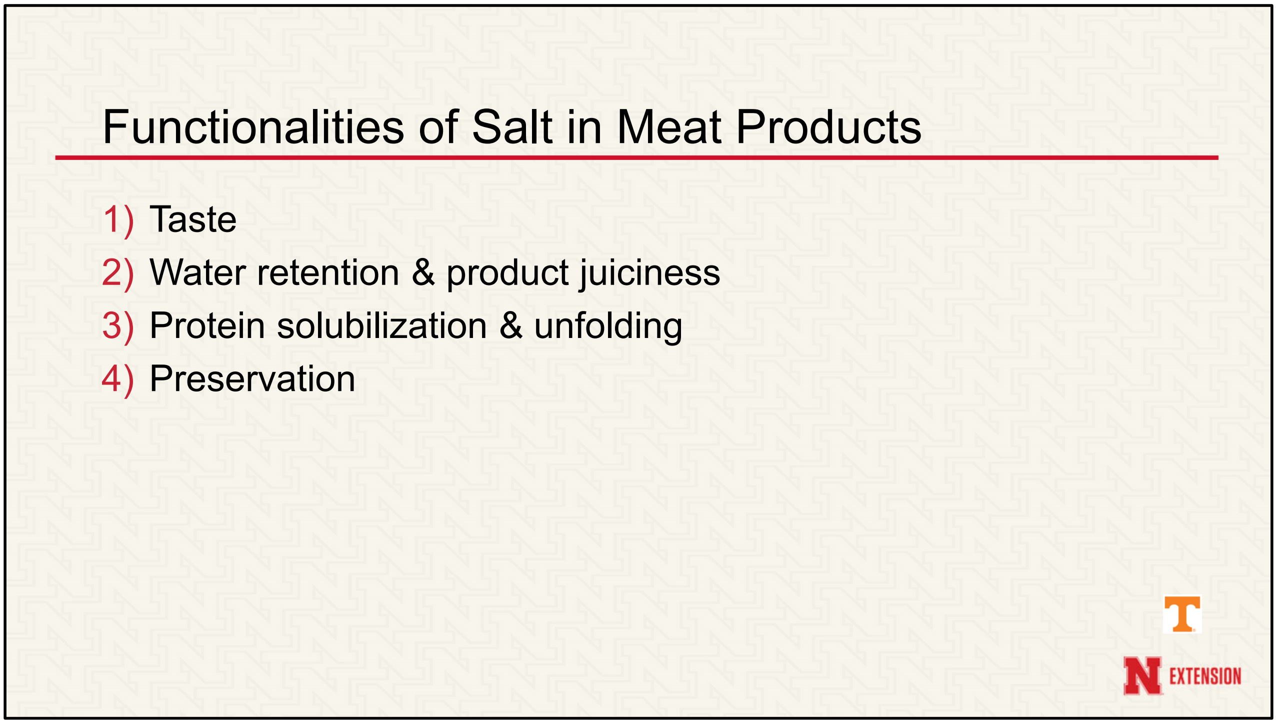
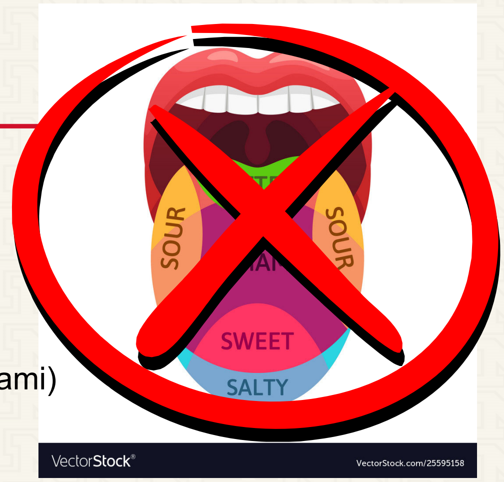


Salt has 4 different functions within meat products including taste, water retention & product juiciness, protein solubilization & unfolding, and preservation. Let's describe these 4 functionalities of salt in more detail.

NEXT SLIDE

Functionality of Salt: Taste

- Salty → 1 of 5 basic taste buds
  - Bitter, Sour, Sweet, Salty, and Umami
- Na^+ interacts with taste bud → "salty"
- Perception of "bitter" is reduced
  - Enhances other flavors (sour, sweet, umami)



As you likely know, salt is one of 5 basic taste buds, along with bitter, sour, sweet, and umami present on the tongue. What's umami, you ask? Umami detects savoriness which is detected in broths and cooked meats.

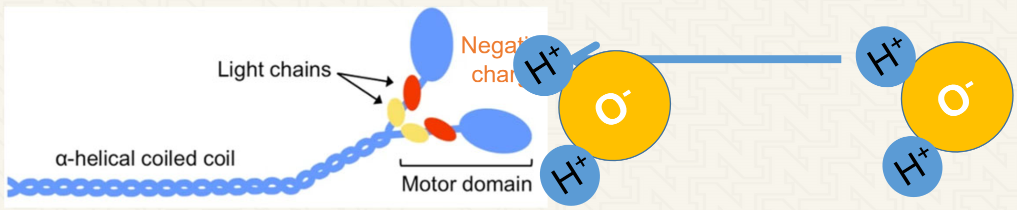
Now, this graphic indicating locations of taste buds on the tongue is (CLICK) wrong. It was disproven in the 1970s but is still taught even today. All of these taste buds are actually intermixed across the tongue surface.

Regardless (CLICK), the sodium interacts with "salty" taste bud. Not only do we taste salt, but (CLICK) the perception of any bitterness is reduced thereby allowing any other flavors (sour, sweet, umami) to be enhanced. The addition of salt functions to make a food taste more like itself. It brings out those flavors we desire.

NEXT SLIDE

Functionality of Salt: Water Retention

- Cl^- interacts with myosin (primary muscle protein)
- Increases net negative charge on myosin
- Attracts positive pole of water molecules (hydrogen side)
- The Result …
  - Less water loss when cooking
  - Greater product juiciness when consumed



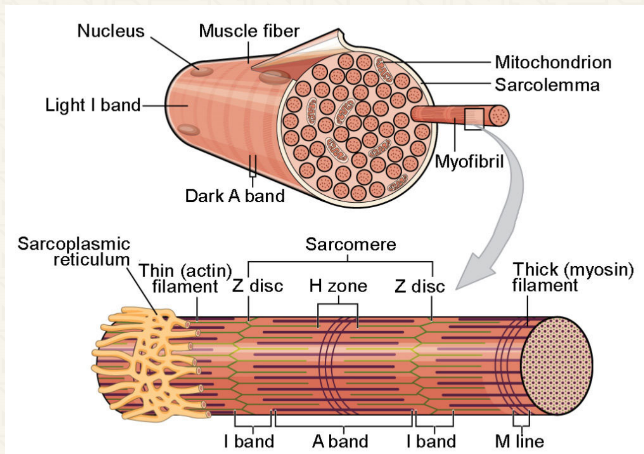
While the sodium ion primarily affects flavor, the chloride ion is responsible for physically changing the structure and electrical charge of meat protein. The chloride anion (Cl^-) interacts with the muscle protein myosin (CLICK) and increases the net negative charge on that protein. The increase in net negative charges on myosin (CLICK) functions to attract the positive pole of water molecules (the hydrogen side).

CLICK -- Because of this interaction, the water molecules are held more tightly in the meat resulting in less weight loss during cooking. When eating the meat, the enhanced moisture retention provides for greater juiciness.

NEXT SLIDE

Functionality of Salt: Protein Solubilization & Unfolding

- Basic Muscle Structure

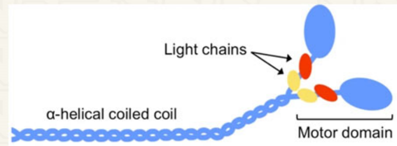


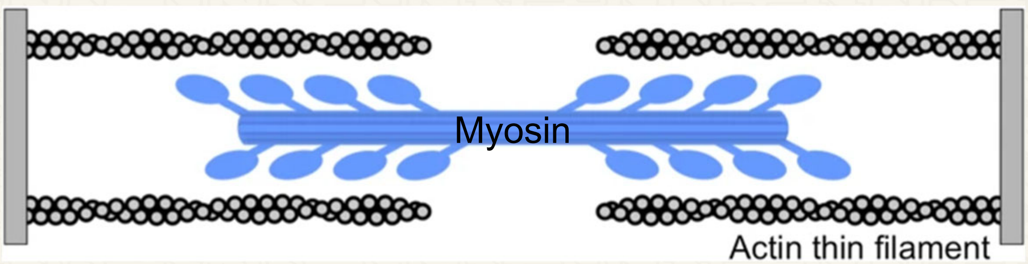
This picture illustrates how muscle tissue is structured. Each muscle fiber encases hundreds, perhaps thousands of myofibrils. You'll also notice that the muscle fiber has light and dark bands that correspond with overlapping proteins to facilitate contraction and movement.

NEXT SLIDE

Functionality of Salt: Protein Solubilization & Unfolding

- Sarcomere – the smallest contractual unit of muscle
  - Comprised of overlapping protein filaments
    - Thick filament = Myosin (80%)
    - Thin filament = Actin (20%)





Lee, L.A., Karabina, A., Broadwell, L. J. et al. The ancient sarcomeric myosins found in specialized muscles. Skeletal Muscle 9, 7 (2019). https://doi.org/10.1186/s13395-019-0192-3

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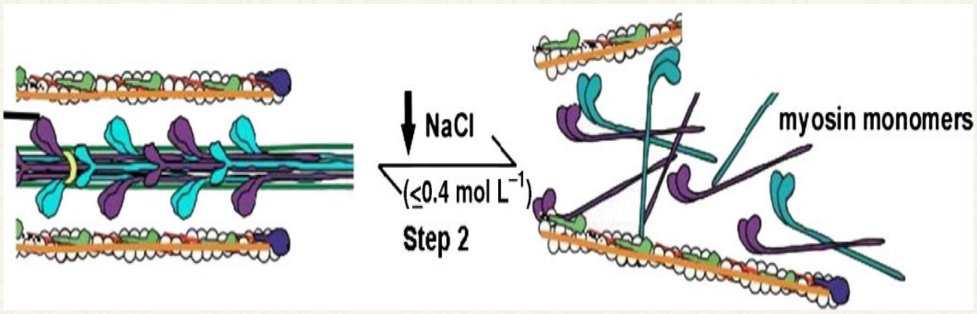
The sarcomere is the smallest contractual unit of muscle that is (CLICK) comprised of overlapping protein filaments within a parallel structure. The thick filament is associated with a protein called myosin. This protein makes up approximately 80% of the protein in muscle tissue. A closeup (CLICK) of myosin indicates that it consists of a coiled tail with two heads. In living muscle, the heads of myosin in the presence of ATP or adenosine triphosphate connect to a binding site on (CLICK) actin or the thin filament, then contract and release to facilitate movement.

NEXT SLIDE

Functionality of Salt: Protein Solubilization & Unfolding

- Salt disrupts the sarcomere structure



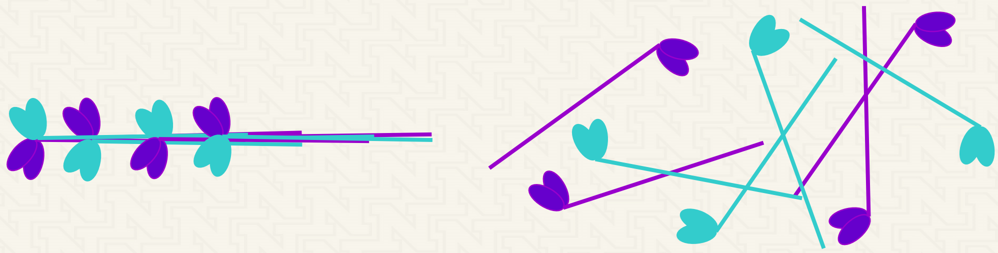
J. Sci. Food Agric, Volume 96, Issue 6, Pages 2033-2039, First published, 17 June 2015, DOI: (10/1002/jsfa.7314).

When salt is added to a meat product, the increased negative charges associated with the chloride ions disrupt this formalized parallel structure of muscle proteins.

NEXT SLIDE

Functionality of Salt: Protein Solubilization & Unfolding

- Cl^- → myosin proteins unfold → sticky/tacky



Xiong, 2007, Meat Binding: Emulsions and batters, AMSA Meat Processing Series

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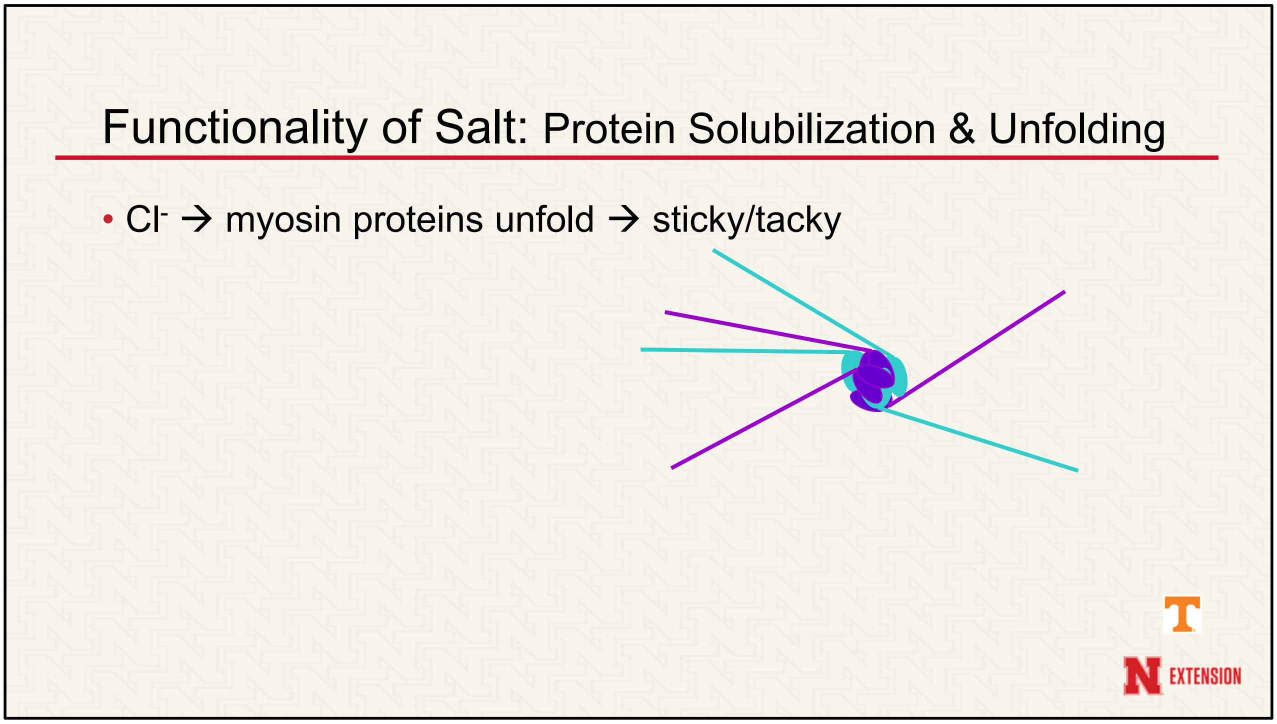
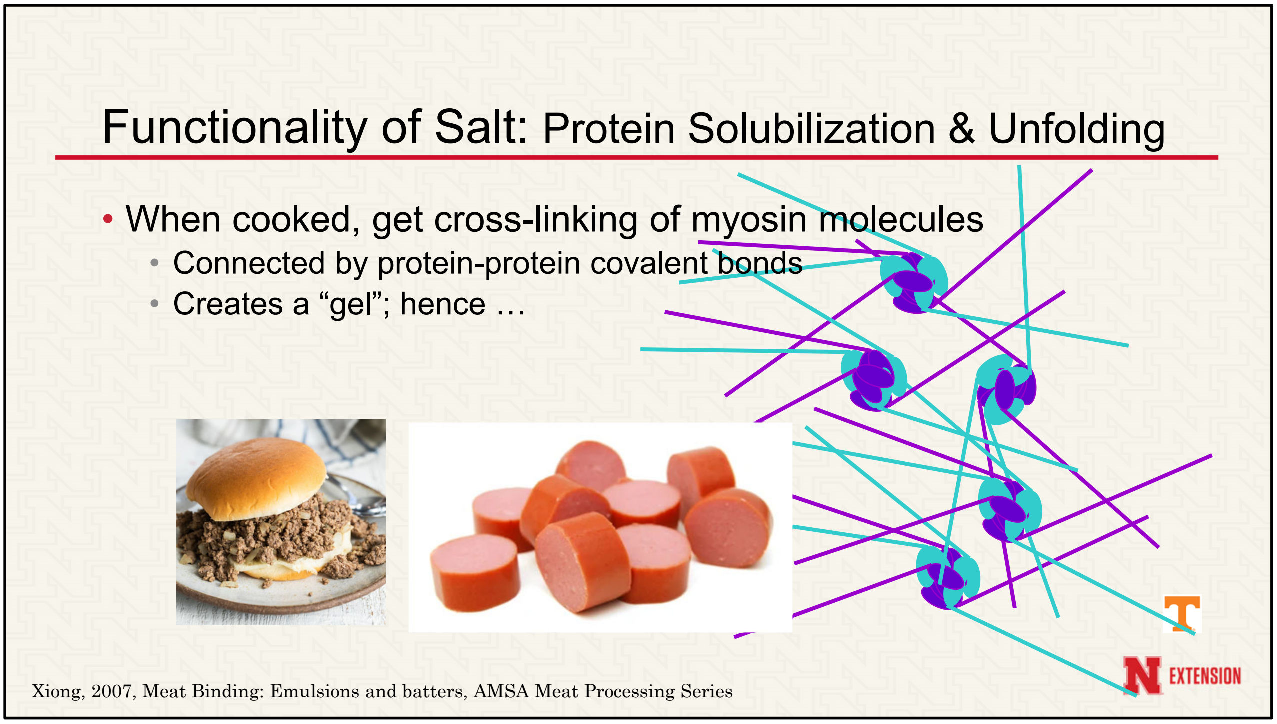
When chloride anions interact with meat, the myosin proteins unfold (CLICK), and the heads become “sticky” or tacky (CLICK, to NEXT SLIDE)



as the heads bind with one another (CLICK → NEXT SLIDE)

NEXT SLIDE (click)



When cooked, these sticky myosin proteins further cross-link with other myosin molecules through development of protein-to-protein covalent bonds as not only do the heads stick together, but the tails become intertwined together as an increasing number (CLICK) of myosin proteins are disrupted and recombine.

CLICK – Effectively, this creates a solid gel. That is why a hot dog has a cohesive texture, but a hamburger is crumbly. The meat and salt mixture can also be formed into and hold specific shapes when cooked (e.g., a dinosaur-shaped chicken nugget).

Functionality of Salt: Preservation

- Centuries ago, how did people preserve meat?

The final functionality of salt is preservation. In fact, it was the original reason that salt was added to meat products centuries ago, long before refrigeration was ever invented.

How does salt function to preserve meat?

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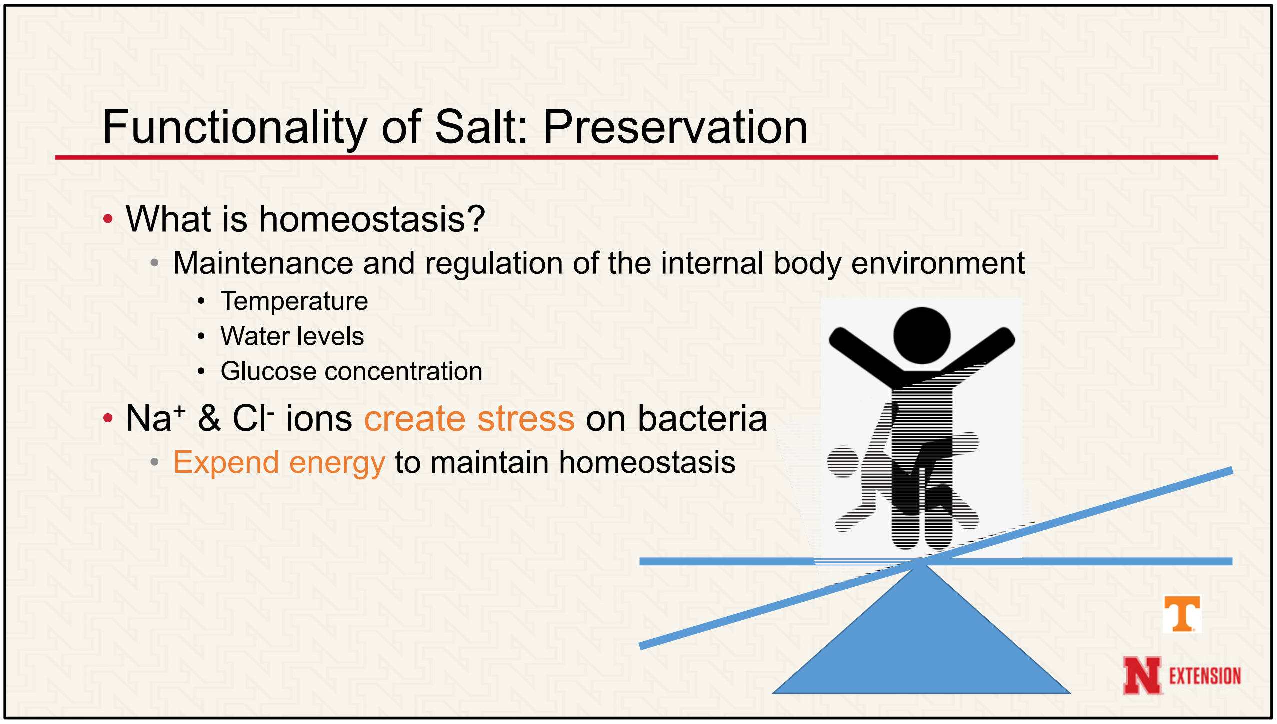


To answer this question, we need to bring in the biological concept of homeostasis. So, what is homeostasis? (CLICK)

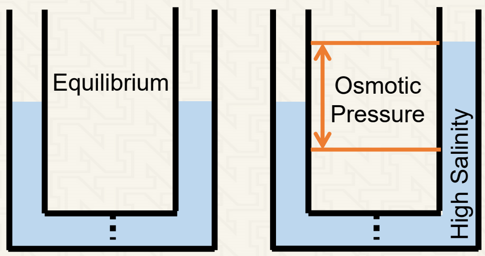
Homeostasis is all about maintaining a biological and chemical balance of the internal body environment relative to such things as body temperature, cellular water level, and glucose concentrations.

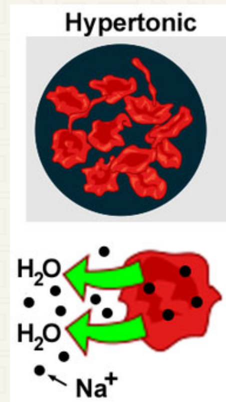
In terms of salt's impact on bacterial growth (CLICK), the sodium and chloride ions create stress on the bacteria as it will have to expend energy to maintain homeostasis.

NEXT SLIDE

Functionality of Salt: Preservation

- Stress related to Osmosis
  - Expend energy to maintain homeostasis
  - Stress = osmotic pressure





  - In hypertonic solution, bacteria spend energy to maintain ionic balance & to keep H_20 from leaving cell

More specifically, the stress is related to osmosis. Osmosis is the primary method by which water is transported into and out of cells. When at equilibrium, everything is balanced.

(CLICK), however, when salt is added and dissolved within that water as we previously discussed, the positive charge of the sodium ion will be attracted to the negative charge of oxygen, and the negative charge of chloride will attract the positive hydrogen components of water. Bottomline (CLICK), the salt draws the water through a permeable cell membrane.

The difference in these two water levels (CLICK) is known as osmotic pressure.

In a hypertonic solution that has sodium and chloride, the bacterium must expend energy to maintain ionic balance and to keep water from leaving the cell. When increased energy is expended to simply maintain homeostatic balance, less is available for reproduction and growth. Thus, the food products are more stable for longer periods of time.

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