The Science Behind Brining

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**What is a Brine and How Does it Work?**

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Brine is a salt and water solution that food products, (most commonly meats), are soaked in to improve overall quality.

**Why Brine?**
- Texture
- Flavor
- Moisture Retention

**How does a Brine Work?**
Most conventional explanations of how brining works describes the movement of salt into the proteins through a process called osmosis.

**Understanding the Concepts of Osmosis and Diffusion as Applied to Brines**

**Air (In a Vacuum)**

**Diffusion**
- Dissolved Gas.

**Water = Solvent**
- Overtime, the “solute” molecules will equilibrate, moving from a higher concentration to a lower concentration.

**Osmosis**
- The approaching molecule will block the opening from the side it is approaching from.
- **Osmosis** is the movement of a higher concentration of water to a lower concentration of water through a semi-permeable membrane.

**Brine in a Container**
- Water
- Chicken Breast
- Salt
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**Understanding the Concepts of Osmosis and Diffusion as Applied to Brines**

**Osmosis** deals specifically with the movement of water from an area of higher concentration to that of a lower concentration, through a semi-permeable membrane.

First, whenever you have less of something dissolved into more of something, you have a **solution**.

So a **brine** can actually be thought of as a salt water **solution**, in which the salt is dissolved in the water.

The thing you have more of in a solution, in this case the water, is called the **solvent**, and the thing you have less of, in this case the salt, is called the **solute**.
If osmosis occurred during the brining process, two things would have to be true:

1. The solute, or the dissolved salt, would have to be too large to penetrate a protein’s outer membrane.

2. If the salt was actually too big to pass through the protein’s outer membrane, then the moisture within the object being brined would actually flow outward into the salt water solution.

We know this is false because the interior of brined meat can obviously become salty.

We know this isn’t true because properly brined proteins are more moist than proteins that haven’t been brined.
Now, the natural question is:

Why do we need salt in the first place? If water moves into a protein through diffusion, why can’t we just soak a protein in water and have it become juicier?

The answer to this is...technically you can. You can soak a protein in pure water, and it will swell, taking on additional water weight, but not as much as if you added salt to the soaking liquid, and more specifically, proteins will not bind to water as effectively during the cooking process unless salt is present.

Now why this actually occurs is extremely interesting and we’ll be discussing this process in more depth, in part two, of this brining video.
How Does a Brine Really Work?

Salt = Sodium Chloride (NaCl)

When salt is dissolved, it breaks into a positively charged sodium ion and a negatively charged chloride ion.

The sodium & chloride ions will diffuse throughout food much like heat does during cooking. Just like heat will flow from hot areas to cold areas, sodium & chloride ions in a brine will flow from areas of higher concentration to areas of lower concentration.

It takes about 100-1,000 times longer for salt to diffuse into food than heat. This is why we roast a pork belly in a matter of hours, but that same pork belly will take 3 months for the salt to transform into pancetta.

Proteins are still modified and bind water more tightly, up to 6% salinity, at which point the muscle fibers will start to contract and squeeze out water.

Why do both dry salt rubs and brines yield juicier meat?

When salt is dissolved, it breaks into a positively charged sodium ion and a negatively charged chloride ion.

Negatively charged chloride ions diffuse into muscle fibers.

The negatively charged ions repel one-another, creating gaps for water to enter.

Food products containing more than 1% salt by weight usually taste overly salted.

This prevents muscle fibers from shrinking and squeezing out water during the cooking process.

If given enough time, the ion content of the brine & food will form an equilibrium, up to a certain point.

Muscle Fiber Zoom

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Brining Strategies

**Dry Rub “Brining”**
Salt is mixed with other dry seasonings such as herbs and spices and rubbed onto the surface of the protein.

A good starting point for the amount of salt being used is around 1% based on the protein's weight.

The “salt rub” is left on for a given period of time (anywhere from 4-48 hours) and is then cooked as is, without being rinsed.

Although this method doesn’t introduce excess water to be absorbed, the salting does allow the protein to bind moisture more tightly.

**Gradient Brining (Traditional)**
Brine usually has 5-10% salt content.

Food is placed in brine for as little as 15 minutes and as long as a few days.

The surface of brined food is rinsed under cold water to remove excess sodium from the surface.

During the resting period, the salt gradient is allowed to “equilibrate,” or finish diffusing.

**Equilibrium Brining (Modernist Cuisine)**
Water and food are weighed together (minus any bone weight).

The combined weight of the water and meat are multiplied by the desired finished salt percentage of the brined food (usually .5-1%).

The appropriate amount of salt is dissolved into the water and the food is placed in the brine.

A salinity meter is used to read the salt content in the surrounding brine. When the salinity of the brine reaches equilibrium, you know that your desired finished salinity has been achieved.
Calculating and Making a Brine

**Gradient Brining**

- Desired Brine Salinity: Usually 5-10% by weight.
- Water Weight: Enough water to comfortably cover food.
- Salt Weight: Added to water.

Ex) $1,000g\text{ Water} \times 0.05\% = 50g\text{ Salt}$

Dissolve salt into water and you’re ready to go.

**Equilibrium Brining**

Using the same amount of water as food is easiest.

When the PPM drops to half of its initial reading, you know that a state of equilibrium has been reached and the food is finished brining.

A salt meter will usually read out in PPM not a percentage.

The water will start at a 2% salinity (assuming that equal amounts of water and meat are used by weight).

**Ex)** Let’s assume that we’re brining a whole, bone-in chicken with a total weight of 5 pounds.

Since the average bone weight of a whole chicken is usually around 40%, we’ll calculate the weight of the bones as follows:

$$5\# \times 0.40 = 2\#\text{ Bone Weight} \rightarrow (5\# - 2\# = 3\#)$$

$$3\#\text{ Water} + 3\#\text{ Chicken (meat)} = 6\#\text{ (Total)}$$

$$6\# \times 0.01\%\text{ (1% Salt)} = 0.06 \times 16 = 0.96\text{ oz} \times 28.3 = 27.1g$$

When equilibrium is reached, the food product is now brined and ready to go.

**Calculating PPM**

1 Parts Per Million Equals 1mg / 1,000g. 1g = 1,000mg. So a 1% salt water solution would be 10g (10,000mg) of salt dissolved into 1,000g (or 1,000,000mg) of water, making the salt content 10,000 PPM.
Tenderizes meat by shortening muscle fibers, but also allows for brines and marinades to diffuse quickly throughout the protein.

Injection

Allows brines and marinades to be directly injected into the interior of a protein, speeding up diffusion.

Vacuum Tumbling

Tumbles proteins and liquids (such as brines and marinades) together under vacuum. The combination of low atmospheric pressure (caused by the vacuum) and the tumbling process, can reduce brine durations from hours and days to minutes.
## 5% Brine Chart

**Please Note:** The times given here are approximation. Please refer to given recipe for more information.

<table>
<thead>
<tr>
<th>Item</th>
<th>Brine Time</th>
<th>Rest Time</th>
<th>% Sweetener</th>
<th>Special Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chicken Breast</td>
<td>4-6 Hours</td>
<td>2-4 hours</td>
<td>3% Sugar or 2% Honey</td>
<td>Allow more time for bone in, skin on. Jaccarding is recommended.</td>
</tr>
<tr>
<td>Chicken Leg &amp; Thigh</td>
<td>8-12 Hours</td>
<td>3-6 hours</td>
<td>2% Sugar or 1% Honey</td>
<td>Allow more time for bone in, skin on. Jaccarding is recommended.</td>
</tr>
<tr>
<td>Whole Chicken</td>
<td>24-48 Hours</td>
<td>8-24 Hours</td>
<td>3% Sugar or 2% Honey</td>
<td>Allow to rest uncovered in refrigerator so that the skin dries out.</td>
</tr>
<tr>
<td>Pork Tenderloin</td>
<td>12-16 Hours</td>
<td>2-4 Hours</td>
<td>3% Honey or 100% Cola</td>
<td>Substitute cola for water. Do not mix with curing salts. Could be lethal!</td>
</tr>
<tr>
<td>Pork Loin</td>
<td>12-24 Hours</td>
<td>4-8 Hours</td>
<td>3% Honey or 100% Cola</td>
<td>Substitute cola for water. Do not mix with curing salts. Could be lethal!</td>
</tr>
<tr>
<td>Pork Chop (Bone In)</td>
<td>2-8 Hours</td>
<td>3 Hours</td>
<td>2% Sugar or 1% Honey</td>
<td>Substitute cola for water. Do not mix with curing salts. Could be lethal!</td>
</tr>
<tr>
<td>Fish Fillet</td>
<td>20 min - 2 Hours</td>
<td>2 Hours</td>
<td>3.5% Sugar</td>
<td>Slightly higher sugar content is need to balance brine for delicate fish.</td>
</tr>
<tr>
<td>Shrimp/Scallops</td>
<td>20 Minutes</td>
<td>1 Hour</td>
<td>3.5% Sugar</td>
<td>Slightly higher sugar content is need to balance brine for delicate fish.</td>
</tr>
<tr>
<td>Lobster</td>
<td>1 Hour</td>
<td>1 Hour</td>
<td>3.5% Sugar</td>
<td>Slightly higher sugar content is need to balance brine for delicate fish.</td>
</tr>
<tr>
<td>Beef</td>
<td>N/A (Mostly)</td>
<td>N/A</td>
<td>N/A</td>
<td>Normally beef is not brined; it tends to benefit more from marinades.</td>
</tr>
</tbody>
</table>