

Sous vide cooking and chemistry

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ACS Webinar — May 9, 2013

How often do you cook?

- (a) Cook almost everyday.
- (b) Not daily, but quite a lot.
- (c) Only for special occasions.
- (d) Almost never.

sous vide /su: 'vi:d/ *adjectival & adverbial phr.*

L20. [ORIGIN French, from *sous* under + *vide* vacuum.]

Of food: (prepared) by cooking in vacuumized pouches at precisely controlled temperatures.

Optimal food temperatures

- ▶ Beef, lamb, and pork

 - ~50 °C Rare

 - ~55 °C Medium-rare

 - ~60 °C Medium

 - >70 °C Well done

- ▶ Fish and shellfish

 - ~49 °C Medium-rare

- ▶ Baked goods

 - ~90 °C Breads, rolls, muffins, etc.

Common kitchen heat sources

~70 °C Slow-cooker

100 °C Boiling water

125–200 °C Oven

150–250 °C Skillet

200–350 °C Grill

1500–2000 °C Blowtorch

Sous vide cooking:

- ▶ Cook at the food's optimal temperature.
- ▶ If 55 °C is medium-rare,
 - then use a 55 °C water-bath
 - ⇒ meat can't exceed 55 °C
 - ⇒ nothing overcooked
 - ⇒ medium-rare from edge to edge

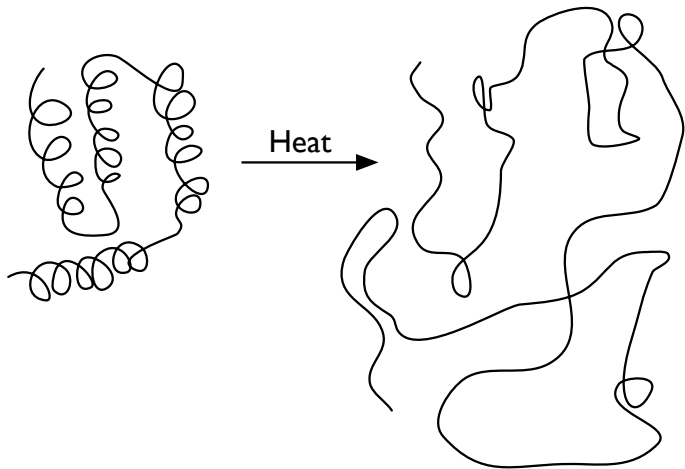
Vacuum-sealing benefits

- ▶ Removing air improves heat transfer
- ▶ Increases shelf-life
 - Food can't be recontaminated
 - Inhibits off-flavors from oxidation
 - Reduces aerobic bacterial growth
- ▶ Improves nutrition and flavor
 - Stops flavor volatile evaporation
 - Stops nutrients leaching into water

Outline

- ▶ Soft-cooked eggs
 - Protein denaturation
- ▶ Beef chuck roast
 - How heating changes meat
 - Extended heating tenderizes
- ▶ Chicken breasts
 - Pasteurizing for safety

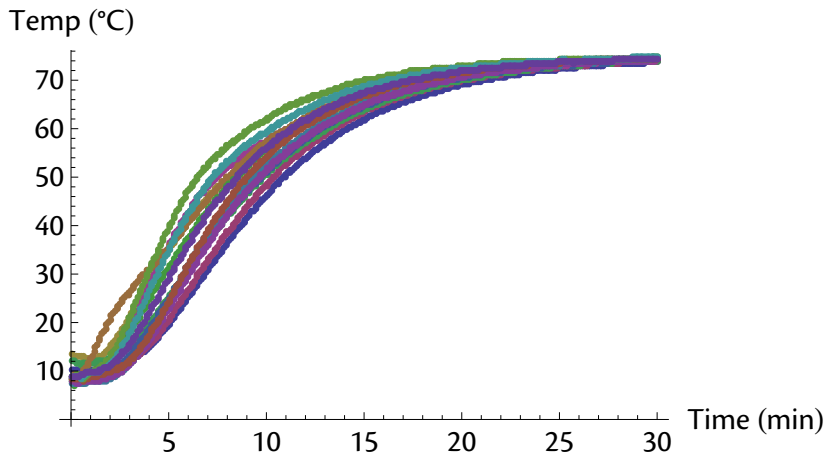
Protein denaturation



Protein denaturation

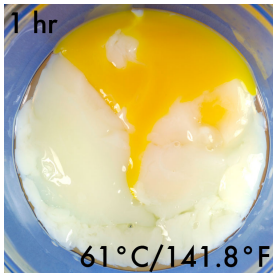
- ▶ Heat — cooking, baking, ...
- ▶ Mechanical agitation — whipping
- ▶ pH change — vinegar, lemon juice, ...
- ▶ Inorganic salts — curing and brining
- ▶ Organic compounds — alcohol marinades
- ▶ Detergents — cleanup

Yolk temperatures in 75 °C water



Measured yolk temperatures of 14 chicken eggs.

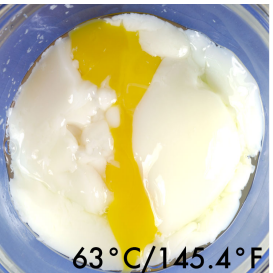
1 hr



61°C/141.8°F



62°C/143.6°F



63°C/145.4°F



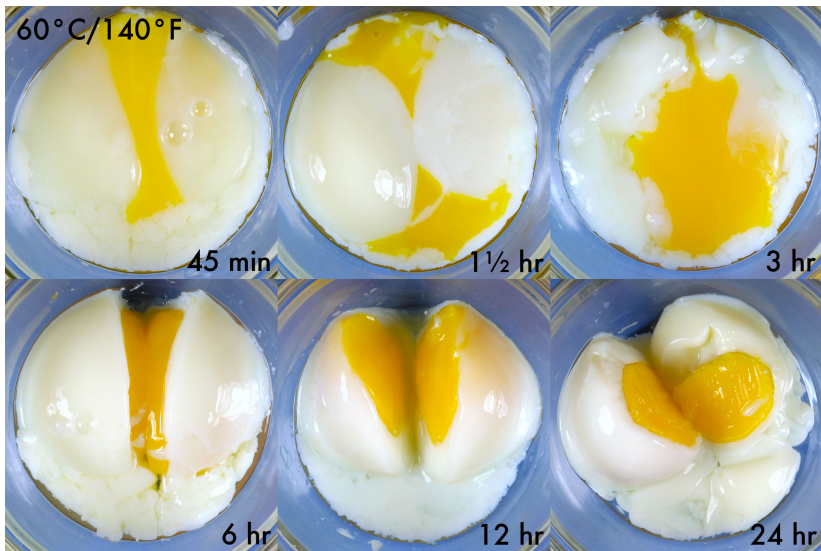
64°C/146.2°F



65°C/149°F



66°C/150.8°F



Reaction rate

- ▶ Temperature
 - Arrhenius reactions:
 - 10 °C increase roughly doubles rate
 - Yolk denaturation:
 - 1 °C increase roughly doubles rate
- ▶ Catalysts
 - Enzymes catalyze biochemical reactions
- ▶ Concentration

When you grill meat or poultry, do you

- (a) always use a thermometer to see when it's done,
- (b) sometimes use a thermometer, or
- (c) never use a thermometer?

Meat proteins

Meat's about 75% water, 20% protein,
and 5% fat and other substances.

Proteins:

- ▶ Muscle fibers
 - mostly myosin & actin
- ▶ Soluble proteins
 - mostly enzymes and myoglobin
- ▶ Connective tissue
 - mostly collagen, less elastin

Meat protein denaturing

In traditional cooking when heating:

- ▶ Muscle fibers shrink
starting 35–40 °C up to ~80 °C
- ▶ Soluble proteins aggregate and gel
starting ~40 °C and finishing ~60 °C
- ▶ Connective tissues shrink
starting ~60 and
more intensely above ~65 °C

Doneness

50 °C Rare — muscle fibers and soluble proteins start denaturing

55 °C Medium-rare — more muscle fibers and soluble proteins denature

60 °C Medium
— most soluble proteins denatured

>70 °C Well done
— connective tissue start denaturing
— muscle fibers squeeze out water

If you eat beef, do you prefer it

- (a) rare,
- (b) medium-rare,
- (c) medium, or
- (d) well done?

If 55 °C is medium-rare,
why not cook at 55°C?

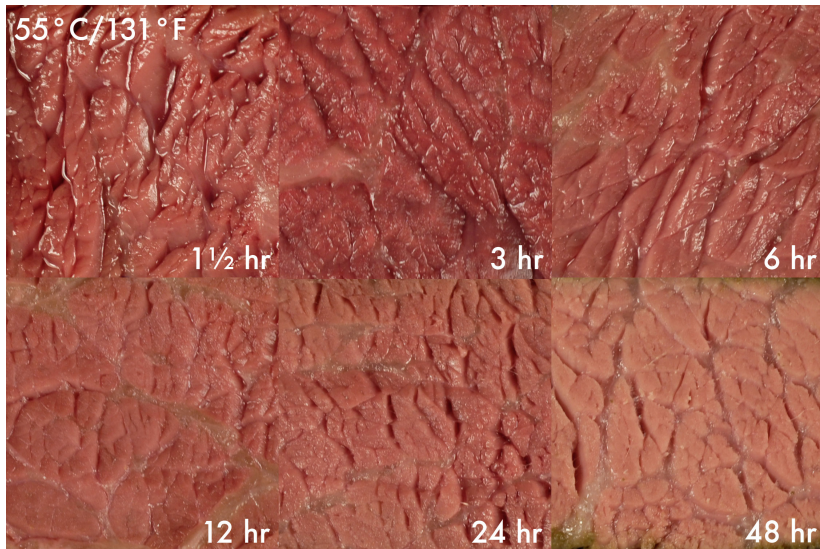
You can with sous vide cooking.

Slower reactions tenderize

Holding meat at 55–60 °C for hours
to days increases tenderness because

- ▶ Enzymes can catalyze
connective-tissue protein hydrolysis
- ▶ Collagen slowly starts to denature
around 51 to 53 °C

Beef chuck roast



Meat flavor

1. Browning or Maillard reaction
 - Roast and savory flavors
 - Starts noticeably $\sim 130\text{ }^{\circ}\text{C}$
 - Good browning starts $\sim 150\text{ }^{\circ}\text{C}$
2. Fat makes
 - lamb taste like lamb and
 - beef taste like beef.

Maillard reaction

- ▶ Complex reaction between amino acids and reducing sugars
- ▶ Produces hundreds of reaction by-products
- ▶ Reaction rate increased by
 - Increasing temperature
 - Adding a reducing sugar
 - Increasing the pH

Rapid browning methods

- ▶ Beef and lamb
 - Butane blowtorch
 - Very hot grill or broiler
- ▶ Chicken and pork
 - Pan with smoking-hot oil
 - Shimmering oil with 4% glucose wash
 - Very hot grill or broiler

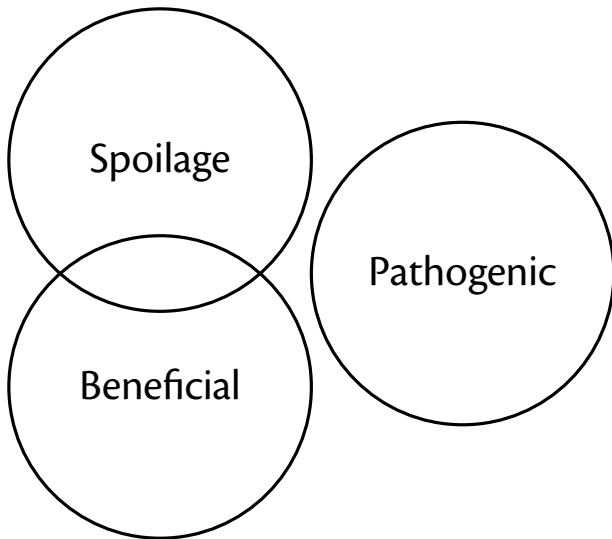
Beef chuck roast

1. Preheat water to 55 °C for medium-rare
2. (OPTIONAL) Pre-sear with blowtorch or grill
3. Vacuum-seal roast in a large pouch
4. Put into water bath for 1–2 days
5. Remove from pouch and pat dry
6. Sear each side to a mahogany brown
7. Season and serve immediately

When do you stop cooking a chicken breasts?

- (a) When it's juices run clear.
- (b) When it's white when you cut into it.
- (c) When it reaches 75 °C/165 °F.
- (d) When it's dry and stringy.
- (e) Some other criteria.

Food microorganisms



Many ways to reduce pathogens

- ▶ Heat — both time and temp important
- ▶ Inorganic salts — curing
- ▶ pH changes — acidifying
- ▶ Herbs and spices — essential oils
- ▶ Mechanical agitation — very high pressures
- ▶ Alcohol — marinades
- ▶ Ionizing radiation — not for home kitchens

“Danger Zone”?

- ▶ Traditional “danger zone” is 5 to 60 °C
- ▶ Food pathogens don’t grow below -1.3 °C
- ▶ Food pathogens don’t grow above 52.3 °C
- ▶ Dangerous growth takes days at 5 °C
- ▶ Pasteurization takes 43 min at 60 °C
but 3 hr 20 min at 55 °C

Pasteurization reduces risk

- ▶ Reduce but can't eliminate pathogens
- ▶ Healthy may need 10^5 to 10^9 to get sick
- ▶ Immunocompromised 1–10/g to get sick
- ▶ 15–20% of US immunocompromised
- ▶ $10^6 \rightarrow 1$ reduction usually recommended

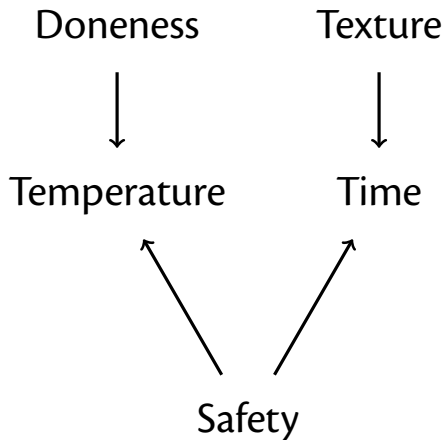
Pathogens of interest

- ▶ *Salmonella* species
- ▶ Pathogenic strains of *Escherichia coli*
- ▶ *Listeria monocytogenes* — the toughest
 - ▶ $10^6 \rightarrow 1$ after 2 min at 70 °C
 - ▶ $10^6 \rightarrow 1$ after 20 min at 62.5 °C
 - ▶ $10^6 \rightarrow 1$ after 200 min at 55 °C
- ▶ Spore forms, like the *Clostridium* species

Sous vide chicken breasts

1. Preheat water bath to 60 °C.
2. Individually vacuum-seal the breasts.
3. Put sealed pouches in water bath.
4. Cook them for at least 2 hours.
5. Remove from bath and pouches. Pat dry.
6. Sear in a skillet with smoking-hot oil.
7. Serve immediately.

Balance time and temperature



Pork chops

- ▶ Medium-rare to medium \Rightarrow 55–60 °C
- ▶ Moderately tender
 - \Rightarrow short to moderate cooking times
- ▶ 60 °C & 20 mm thick
 - \Rightarrow 1½ hours to pasteurize

Filet mignon

- ▶ Rare to medium-rare \Rightarrow 50–55 °C
- ▶ Prized tenderness \Rightarrow short cooking time
- ▶ 50–55 °C & short time \Rightarrow can't pasteurize
 \Rightarrow healthy people only
- ▶ 50 °C \Rightarrow pathogen growth
 \Rightarrow minimize time
- ▶ 55 °C \Rightarrow short time *or* mushy texture

Additional Resources

- ▶ www.DouglasBaldwin.com
 - ▶ Free sous vide cooking guide
 - ▶ YouTube video demos
 - ▶ Review article [IJGFS vol. 1 (2012) pp. 15–30]
- ▶ *D.B.'s Sous Vide for the Home Cook* (2010)
 - ▶ Over 200 recipes
 - ▶ Less technical than website or review article
- ▶ Other food science books:
 - ▶ H. McGee's *On Food and Cooking* (2004)
 - ▶ N. Myhrvold et al.'s *Modernist Cuisine* (2011)