Pastry is like chemistry: just you can lick the spoon

Christelle Alié (NCE)

Context

- **Pastry = chemistry** (≠ you can eat the product)

Follow an experimental protocol, mix ingredients in a certain order in a certain manner to obtain different products

Egg + Sugar + Flour + Milk + Butter

same ingredients can give very different products depending on quantities, state and order of introduction




- **Date : December 6th**

St Nicholas' candies and chocolates



Role of Eggs

- 90% H2O
- 10% Proteins (mainly ovalbumin)
- Traces of minerals and vitamins

- 50% H2O
- 35% Lipids (lecithin)
- 15% Proteins

Beaten Egg Whites

Classic beaten egg whites:

Egg White X g at Room T

- Whip EW (increase speed progressively)
- Whip till fluffy foam

65 g EW → ~ 500 cm^3
Volume 7-8 fold increase

Modified beaten egg whites:

Egg White X g at Room T
+ sugar water (X g H_2O + 0,15 X g sugar)

- Whip EW (increase speed progressively)
- Add progressively sugar water
- Whip till fluffy foam

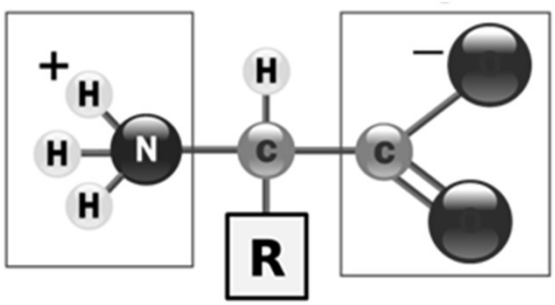
65 g EW + 60 g H_2O +10 g sugar→ ~ 1000 cm^3
Volume 15 fold increase

65 g EW = ~ 2 EW

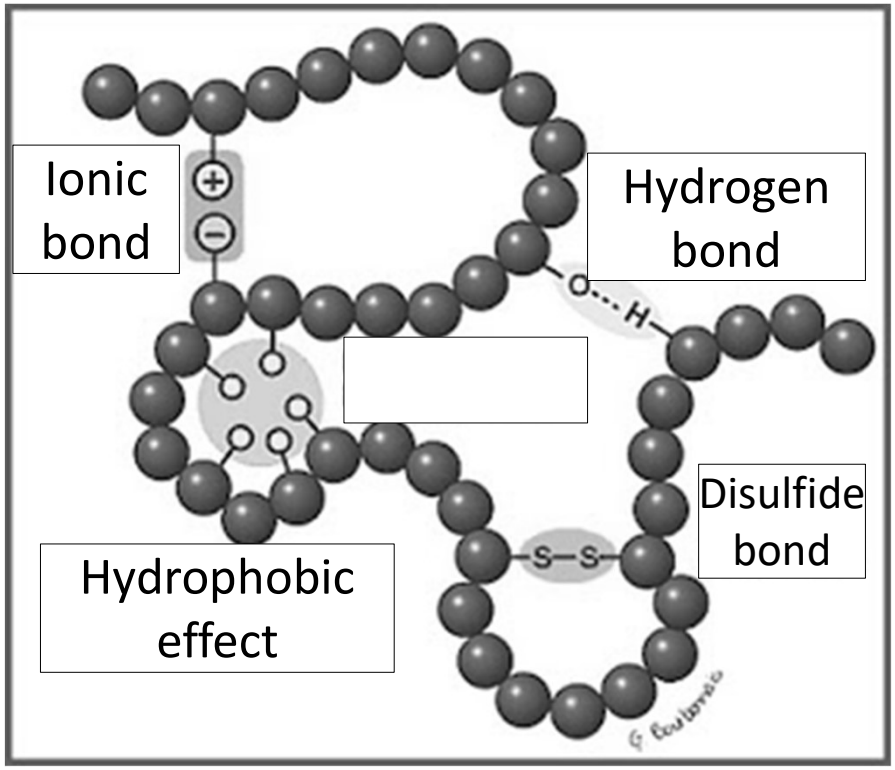
Beaten Egg Whites: What happens

Initial shape : wool ball

Ovalbumin = long chains containing hundreds of amino acids

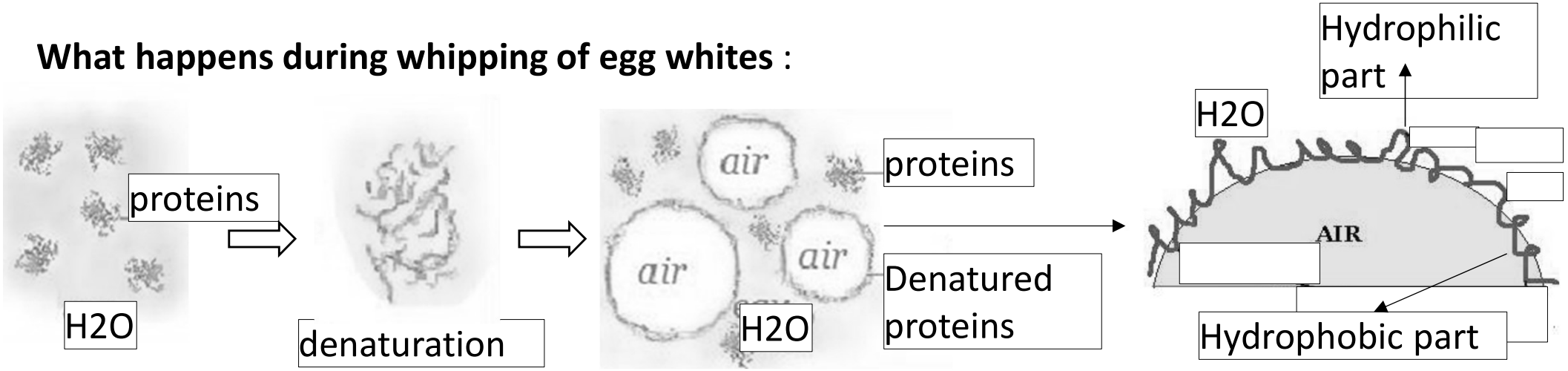


Hydrophilic parts and
hydrophobic parts in protein



Beaten Egg Whites: What happens

What happens during whipping of egg whites :



- **Start with small whipping speed** to introduce air bubbles and increase whipping speed to decrease air bubble size as smaller bubbles are easier to stabilize
- **Bonds** between denatured proteins increase foam stiffness
- **Add of H_2O** dilutes proteins and increases amount of bubbles that can be stabilized

⚠

- **Strictly avoid egg yolk** in EW and beat EW in clean container as lipids compete with proteins for surrounding air bubbles and lipids do not stabilize air bubbles
- **Do not add salt but eventually a few drops of acid** (vinegar, lemon juice)

AC2

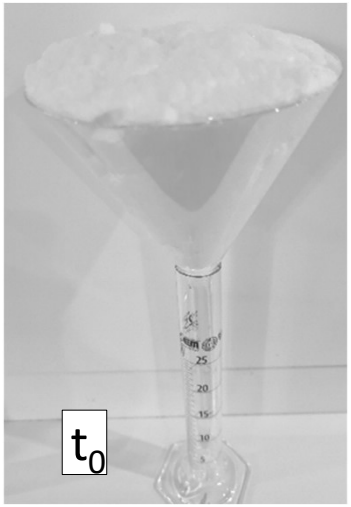
Diapositive 6

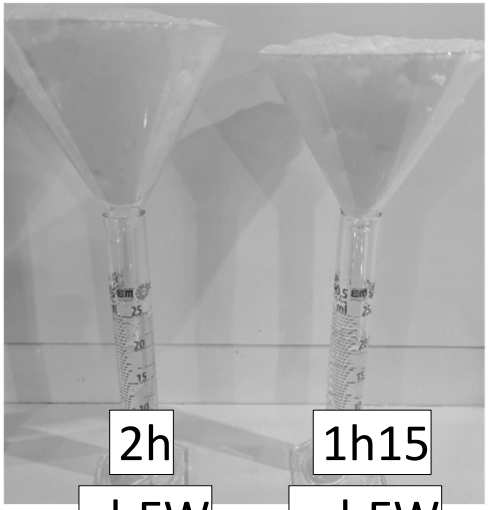
AC2 ajout acide, concentration of H3O+ increases, decreasing the deprotonation of acid functions of proteins => no charging and less repulsion

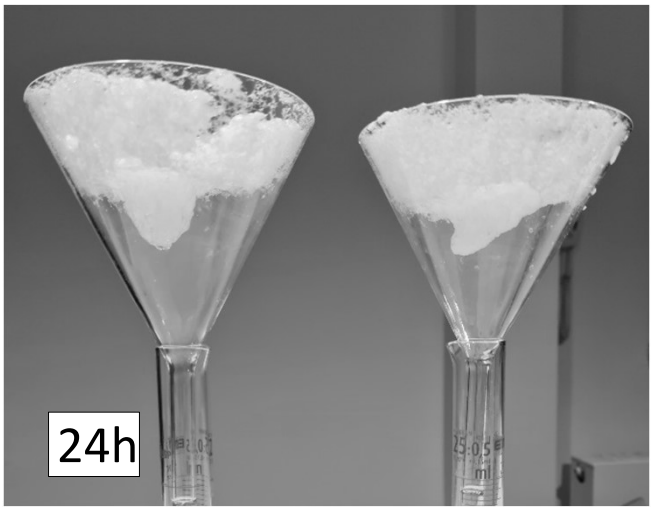
Alie Christelle; 03-12-22

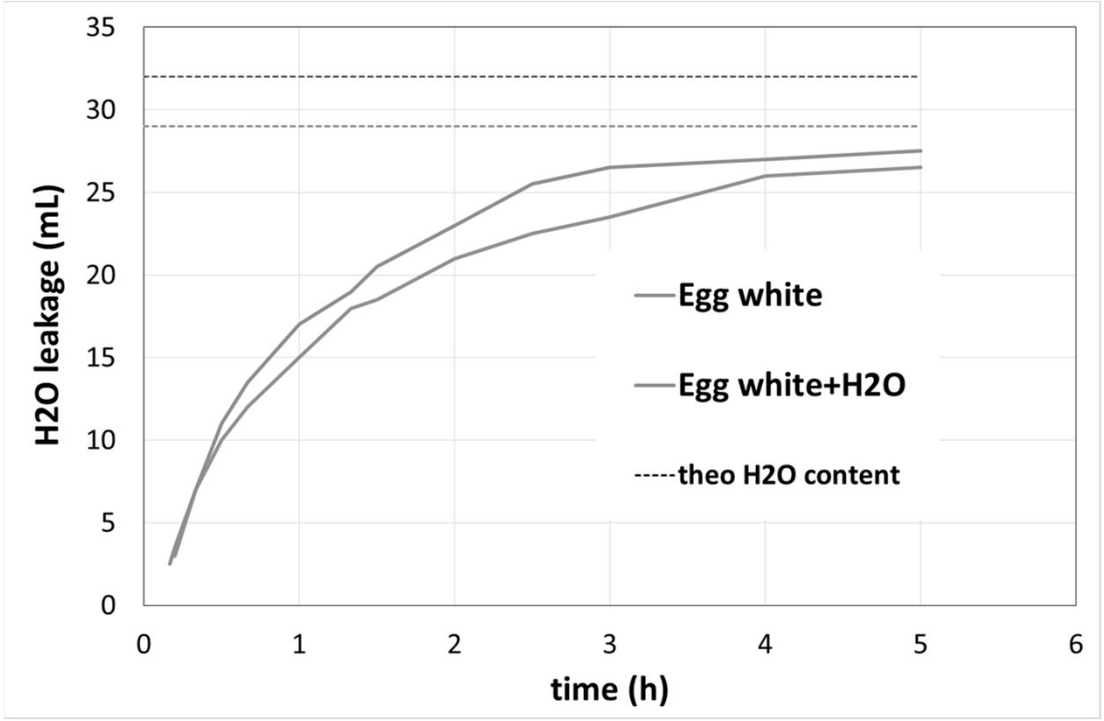
Stability of Beaten Egg Whites

No endless stability because H_2O runoff along proteins and leakage









modified beaten Egg Whites (mbEW) same stability as classic beaten Egg Whites (cbEW)

$\Rightarrow$ As $V_{mbEW} >> V_{cbEW}$, possible to prepare very airy and light chocolate or fruit mousses by adding mbEW to the preparation.

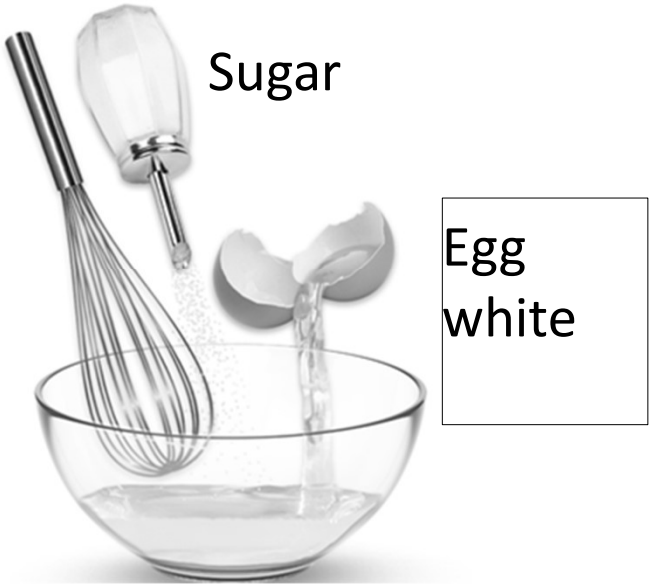
⚠ use beaten EW immediately

3 types of Meringues

French Meringue:

Egg White X g at Room T
+ 2 X g superfine sugar

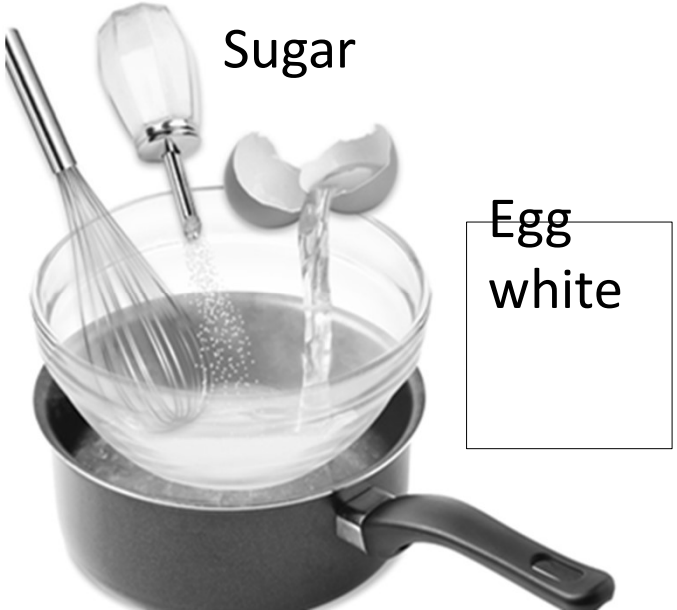
- Whip EW (increase speed progressively) and **add sugar progressively while whipping**
- Whip till stiff glossy peaks



Swiss Meringue:

Egg White X g at Room T
+ 2 X g superfine sugar

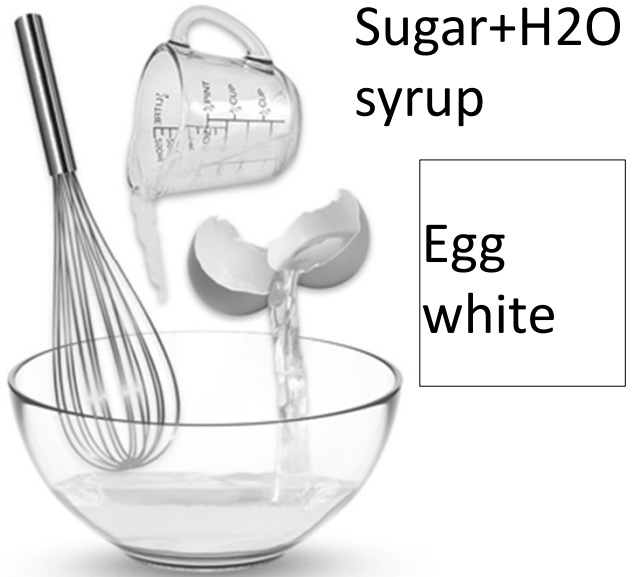
- **Whip EW+sugar over double boiler till 45-50°C**
- Whip to cool down till stiff glossy peaks



Italian Meringue:

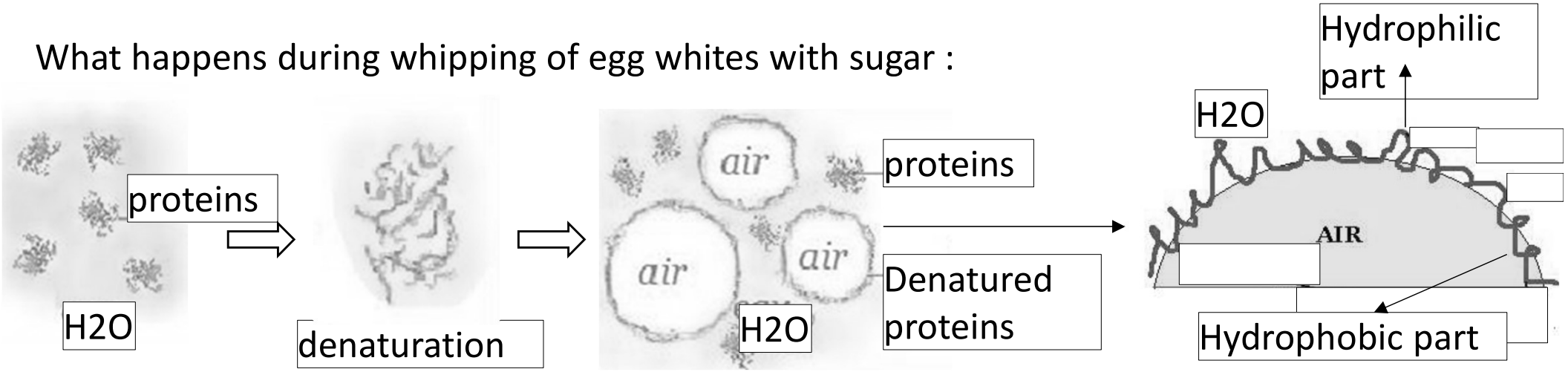
Egg White X g at Room T
+ 2 X g superfine sugar
+ 0,85 X g H2O

- Heat H2O+sugar till 118°C
- Whip EW when sugar syrup around 90°C
- **Add hot syrup to EG while whipping**
- Whip to cool down till stiff glossy peaks



Meringue : What happens

What happens during whipping of egg whites with sugar :



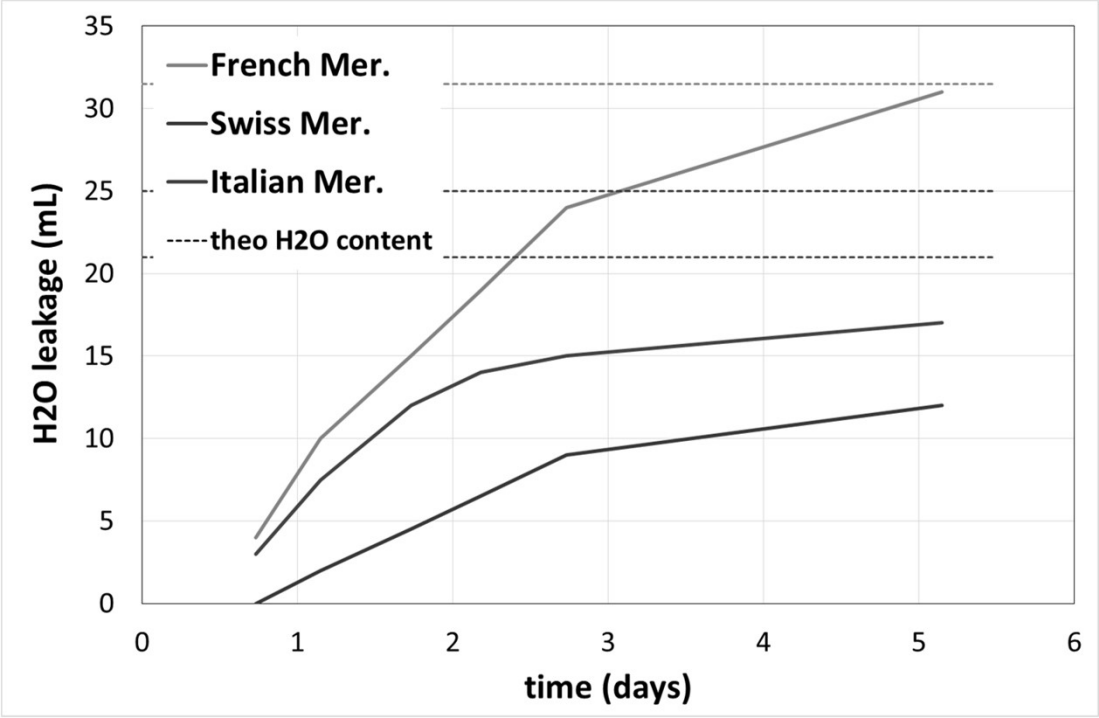
Sugar stabilizes EW in two ways :

- Sugar inserts between proteins to limit excessive bonding between proteins
- Sugar is hygroscopic and retains water inside meringue

Italian meringue : hot syrup induces coagulation of EW and part of H_2O in foam vaporizes but vapor is trapped in EW structure $\Rightarrow$ V ↑↑↑

As mixture cools down, sugar crystallizes $\Rightarrow$ glossy aspect of meringue

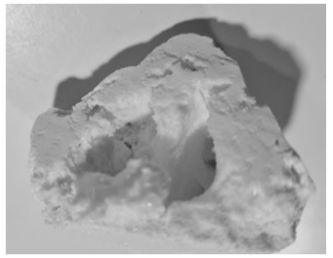
Stability of Meringues



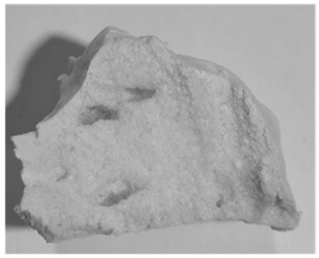
Stability strongly influenced by heating during EW whipping

After 1h30 cooking at 100 °C

French mer.



Swiss mer.



Italian mer.

Applications:

Role of Egg Yolk

- **Moistening and binding agent**
- **Traps air bubbles**

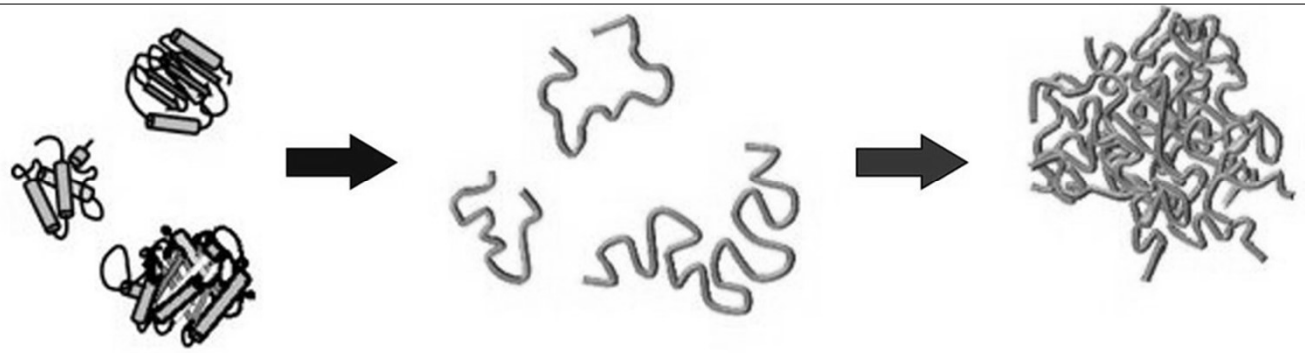
Egg Yolk + Sugar ⇒ white preparation (V ↑)

Egg Yolk + hot Sugar Syrup ⇒ white airy preparation (V ↑↑↑)

⇒ very airy mousses

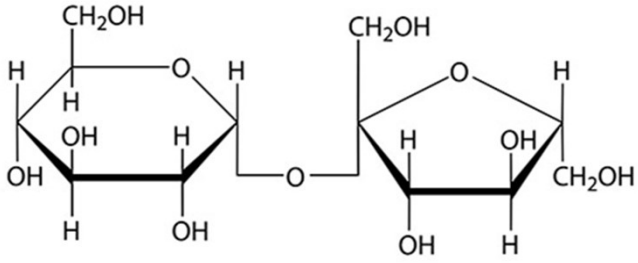
- Proteins of Egg Yolk are involved in **coagulation** of preparations **during heating**

Upon heating	denaturation	coagulation

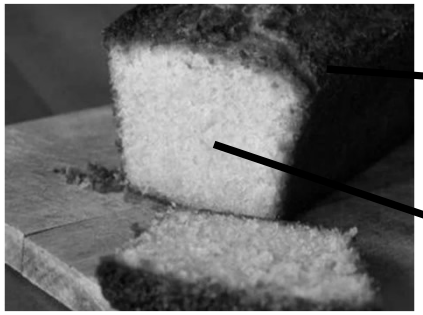


Wound proteins	denatured proteins	aggregates

Role of Sugar



- **Saccharose + $H_2O \rightarrow$ Glucose + Fructose**
- **Flavor** (sweet taste)
- **Color**
- When heated, sugar **caramelizes** (set of simultaneous and successive reactions $C_{12}H_{20}O_{10}$ dianhydride de glucose : caramel smell) or undergoes a **Maillard reaction** (browning) if proteins are present (eg: characteristic brown color of cake crust)



- Partial dehydration of cake exterior (T >150°C):
  Maillard's reaction between sugar + protein (amino acids)
  $\Rightarrow$ aromatic compounds (brown smelly crust)
- Cake interior <100 °C $\Rightarrow$ no browning

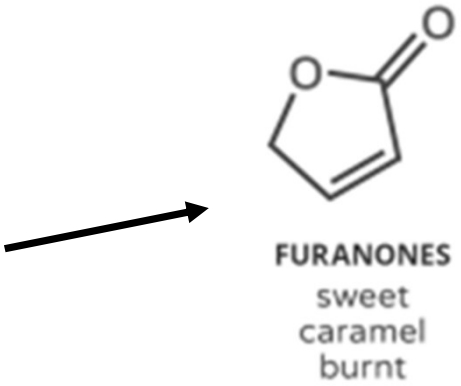
- **Volume**
  Add volume to Egg white, Egg Yolk, Butter while whipping
  Add volume to baking by increasing T of protein coagulation
- **Softness**
  Increase softness by hindering gluten formation
- **Humidity**
  Sugar hygroscopic, retains H_2O in baking $\Rightarrow$ softness
- **Crunchiness and Conservation**

Role of Flour

- **Proteins**
  - **Form gluten** when in contact with liquid ⇒ elasticity and favors dough raise
    Gluten formation can be controlled by addition of Sugar and/or Fats
    Initially proteins form "wool balls" due to intramolecular hydrogen and disulfide bonding and after dough kneading : proteins unfold and align

— Intermolecular disulfide
— Intramolecular disulfide
O Non covalent bonding AC1

  - Give taste by participating to **Maillard's reaction** with sugar
    Sugar + amino acid → glycosilamine + H_2O
    isomerization of glycosilamine → ketosamine
    numerous reactions of ketosamine → many products



- **Starch** (= carbohydrate = 70 % of flour weight)
  - Responsible of H_2O absorption in dough during baking
    T > 50-70°C : Hydrogen bonding between starch molecules and H_2O, H_2O penetrates starch grains and make them swell (**gelatinization**)
    ⇒ Helps to keep cake structure after baking

Diapositive 13

AC1 a) protéines associées par des liaisons disulfures intermoléculaires conférant une certaine élasticité à la pâte.
b) protéines associées par des liaisons non covalentes intermoléculaires conférant une certaine viscosité à la pâte.
Alie Christelle; 03-12-22

Role of Raising agents during heating

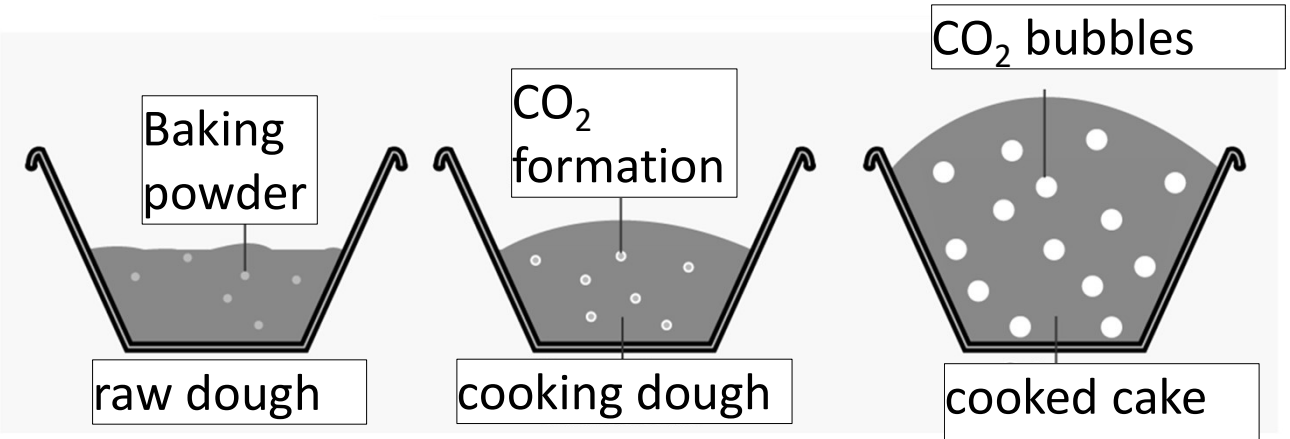
1. **Air** slight effect due to low dilatation
2. **H_2O** liquid $\Rightarrow$ gas volume >>>
3. **CO_2** : Sodium bicarbonate and/or Baking powder (tip: mix with flour before adding)
   - Sodium bicarbonate

$$2\ NaHCO_3 \rightarrow Na_2CO_3 + H_2O + CO_2$$

(Problem Na_2CO_3 reacts with lipids by saponification, better use in combination with acid)

- **Baking powder = sodium bicarbonate + acid + cornstarch**

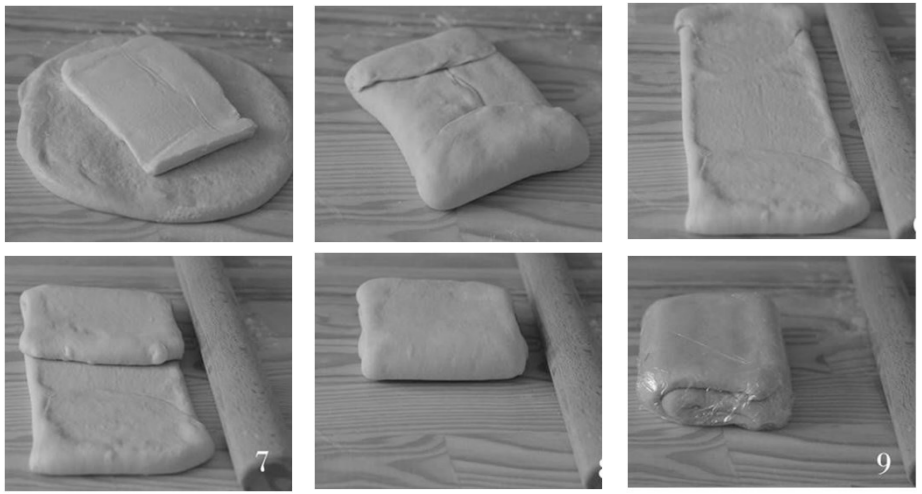
$T > 50°C$ $\qquad NaHCO_3 + R\text{-}H \rightarrow CO_2 + R\text{-}Na + H_2O$

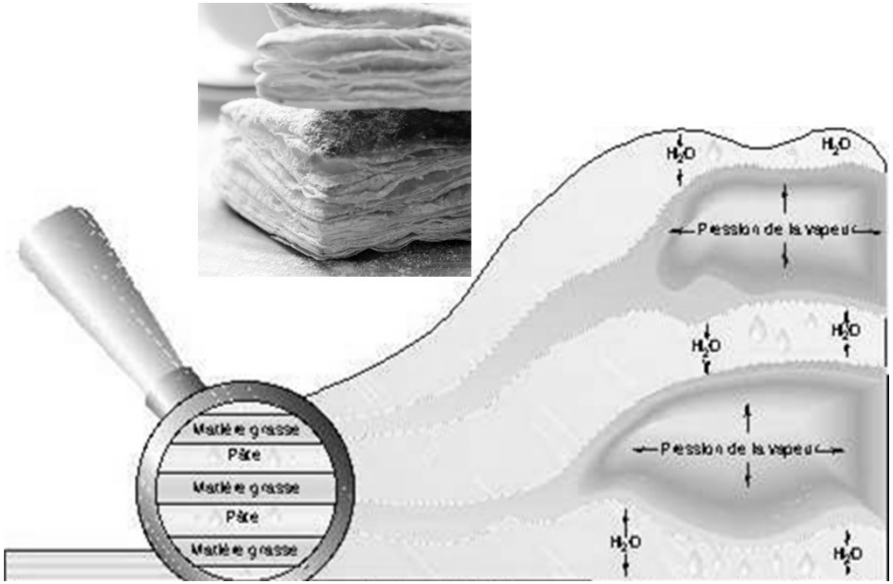


Role of Fats

- **Cake texture different depending on butter texture**
  hard ⇒ brittle dough (shortbread), soft ⇒ airy soft dough (sponge cake) or melted ⇒ dense soft dough (pancakes)
- **Flavor vector**
- **Tenderize**
  Fats induce shortening of gluten network by protein coating
- **Aerate**
  Solid Fats (butter) incorporate air in preparation while whipped with sugar
- **Delay staling**
  Staling = crumb hardening due to structural change of starch
- **Make puff pastry**
  Butter layers melt during heating, is incorporated in dough and leaves space for expanding gas

After 6 rolling out ⇒ over 2000 "sheets" (3^7)





Application : Cakes

- **Butter + sugar** incorporation of air through friction of sugar crystals with butter
- + **egg at RT** (as cold eggs → less volume) AC4
- **Flour sieved with baking powder** (→ less clumps and better mixing)
- **Flour chocolate chips, fruits, nuts** otherwise they end up at the bottom of the mold.
- **Flour and liquid added alternatively** starting and finishing with flour

1st add of flour no gluten formation as proteins completed coated by lipids, once liquid az added, every non-coated protein will generate gluten

Alternate adding enables to generate enough gluten to give structure to cake without making as it compact and heavy. **Do not mix too long at that stage.**

- **Color of mold** has importance : dark mold absorbs more heat so cake bakes faster
- **Oven T** affects aspect and texture: the more eggs, milk and flour are long to coagulate, the more the bubbles have time to swell the cake.
- **Do not open oven** during first 15' as cake structure is not yet established

AC4 (increase whipping rate progressively to maximize volume)

Alie Christelle; 05-12-22

AC3

Application : Pastry cream

Few Ingredients : Egg Yolk + sugar + milk + cornstarch but … not so simple !

- Heat Milk (whole milk → smoother and more flavored cream) + Flavor (eg vanilla)
- **Egg Yolk + Sugar : whip immediately** (if not, clumps), not necessary to whiten mixture

  + Cornstarch
- **Add hot milk progressively to mixture** (if not, egg will coagulate → clumps)
- **Cook on heat again carefully : mix continuously and do not overheat**

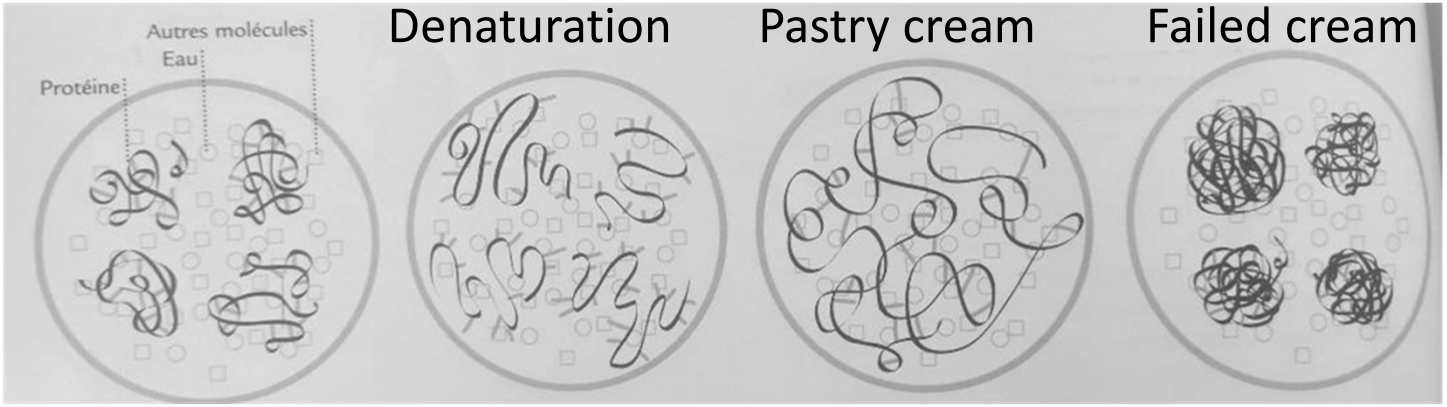
why: - mixing induces good heat diffusion and good intercalation of starch that gelatinizes aaeerrrr and proteins that form network

- overheat induces coagulation of egg yolk

- **Cook till bubbles appear** and continue 1' while mixing

otherwise: - enzyme of starch not inactivated → cream texture will not be maintained

- flour-taste due to insufficient cooking of starch



Diapositive 17

AC3 aussi custard cream

Alie Christelle; 04-12-22

Alternatives

Flour :

- Replace 60% by almond powder (or hazelnut powder)
- Replace 50% by cornstarch
- Replace 25% by ground flaxseed

Butter :

- Replace by oil (80% oil 20% H2O)
- Replace by oleaginous puree or white cheese/mascarpone
- Remove up to 25% of fats
- Lighter : replace by apple compote or zucchini puree or avocado puree

Egg :

- replace by apple compote, yogurt or mix cornstarch+H2O
- Replace by ground flax/chia seed+water

Egg white :

- Replace by chickpeas water

Sugar :

- Replace by honey, agave syrup, maple syrup, stevia, date puree
- Replace part of sugar by equivalent amount of apple compote and remove ¼ part of liquid
- Decrease sugar by 20-25% possible

Milk :

- Replace by vegetal milk

Thank you for your attention

It’s your turn to use your creativity