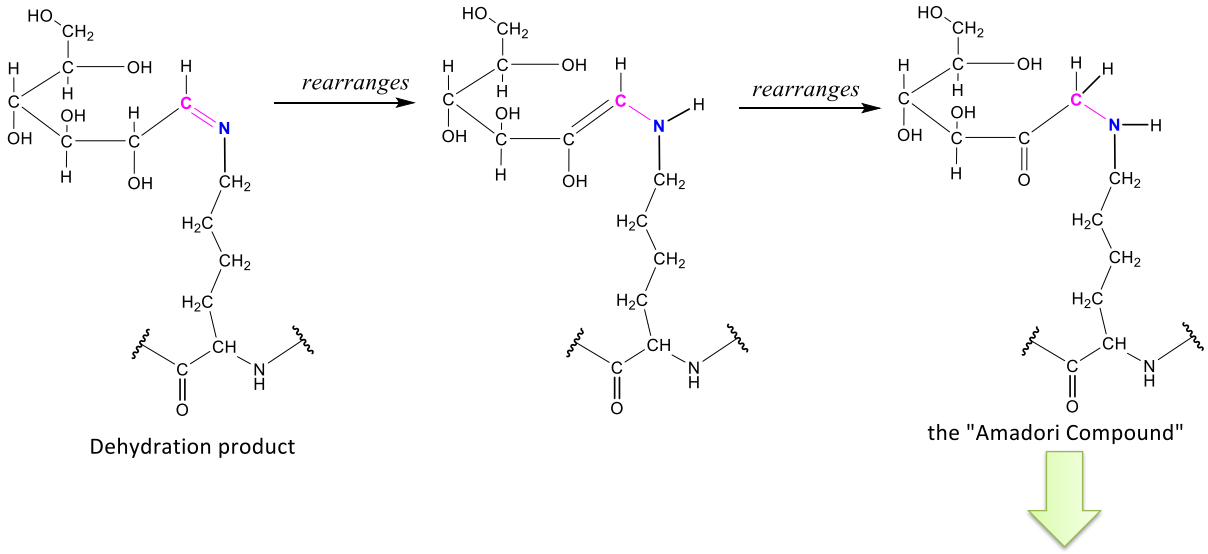
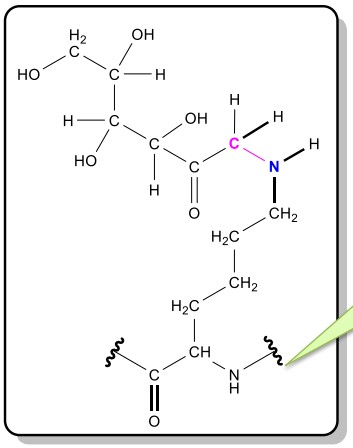
How does Maillard browning work?

Step 3 - Rearrange



Brown colored molecules



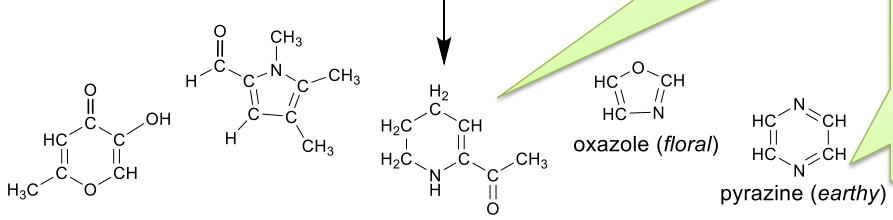
the "Amadori Compound"

There are many possible Amadori compounds from different combinations of sugars and amino acids, these different Amadori compounds break down to yield different flavor and aroma molecules.

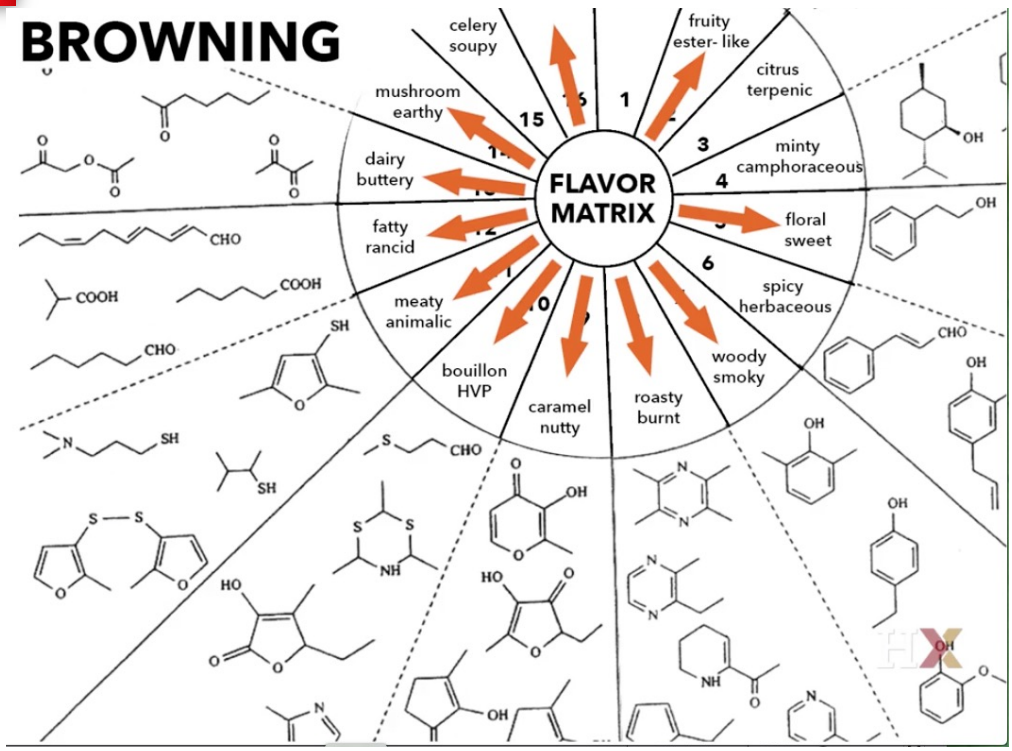
Heat (250°F/120°C)

large brown molecules are also produced -giving the characteristic brown color of toasted bread or seared meat

These are only some examples of the many possible molecules that give browned meat and toasted bread their complex flavors. The products of the Maillard reactions with different amino acids yield flavors ranging from floral and leafy to earthy and meaty.



Aroma molecules made from the Maillard reactions include nitrogen atoms and sulfur atoms (not shown) from the amino acids.



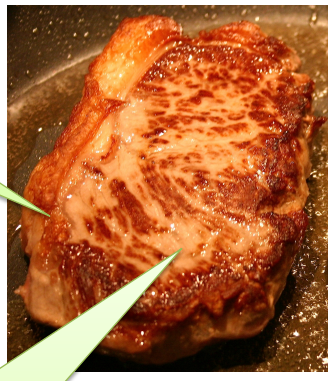
What can undergo the Maillard reaction?

Anything with sugars and amino acids

– Crusty bread, seared meat, vegetables and beer

Maillard Browning

Sugars come from the breakdown of animal "starch" called glycogen



Amino groups are part of amino acids that come from the breakdown of the animal muscle – which is protein

Sugars may be added, but also come from the breakdown of amylose and amylopectin

Amino groups are part of amino acids that come from the breakdown of protein

What about caramelized onions?

A misnomer

This browning is not due to the formation of caramel. It is Maillard browning.

Caramelization

Caramelization...

– Popular culture, cookbooks and many web sources get caramelization and Maillard “browning” mixed up – beware!

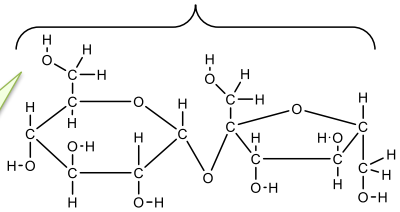
– Caramelization – provides brown color but is a reaction without enzymes using ONLY sugar and heat
  • no amino acids are used in this reaction.

	Caramelization	Maillard Browning
Starting materials	Pure sugar	Sugars and amino acids
Heat	320-350°F	250°F
Flavor	Buttery, sweet, toasty	Meaty, earthy

Caramelization

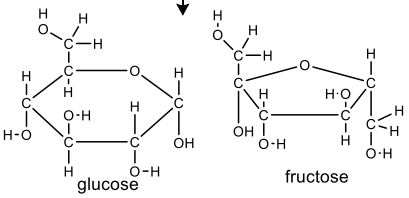
During caramelization, the sugar appears to "melt" when it is actually undergoing a variety of complex chemical reactions

sucrose (i.e. table sugar)



acid helps to break down sucrose

Decomposition of sucrose (320°F/160°C)



glucose and fructose undergo complex chemical reactions from the heat

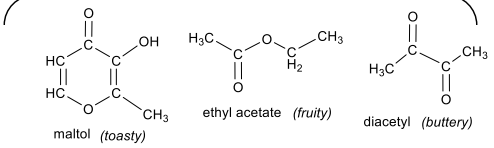
chemical reactions remove many water molecules

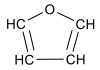
$C_{12}H_{12}O_9$ caramelan, $C_{24}H_{26}O_{13}$ caramelen, $C_{36}H_{18}O_{24}$ and caramelin

decomposition into aroma molecules (requires heat)

The combination of color, semisolid texture, and aroma is from the complex mixture of the aroma molecules and the caramelans

these are only some of the products - other molecules are formed as well





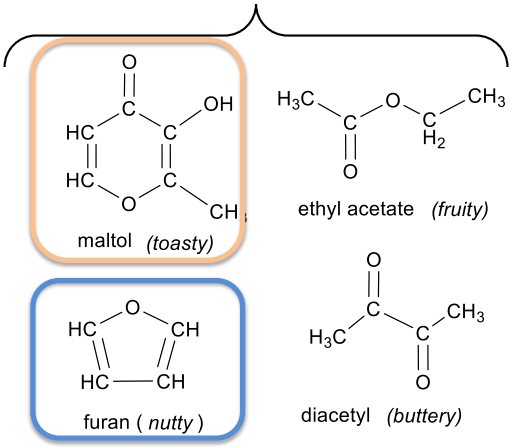
These molecules are volatile - they easily escape into the air travel into our noses and bind to our smell receptors.

The caramelans are large brown colored molecules. These large molecules give the mixture its brown color and semisolid texture

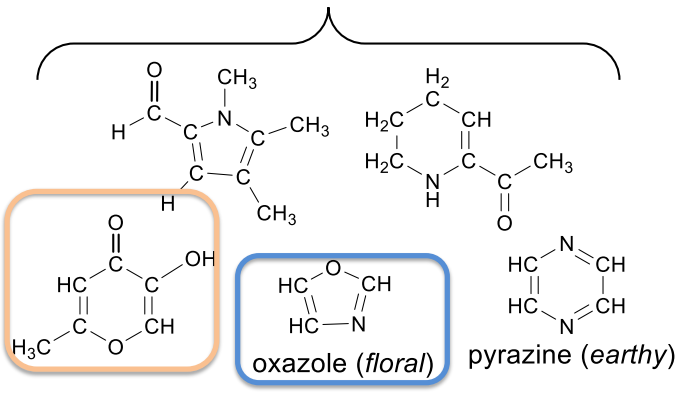
Caramelization vs Maillard aroma

Aroma molecules made from the Maillard reactions include nitrogen atoms and sulfur atoms (not shown) from the amino acids and these aromas *smell differently.* But they still share similarity in aroma.

Some of the aromas from caramelization



Some of the aroma molecules produced in the Maillard Reaction



Similar structure = similar aromas/flavors

Caramel begins with browned sugar

Caramelization products are classified into three groups

Caramelans (12 Carbons)

– formed by loss of water after shorter cook times, smaller molecules with bitter taste and nutty/light-brown color

Caramelens (24-36 Carbons) -

– are larger polymers produced after longer cooking times, loss of 8 H_2O

Caramelins (36-125 Carbons)

– dark intense flavored large polymers poorly dissolved in water

Maillard and Caramelization?

Intermediates of both browning reactions will form new complexes with each other –

- chocolate, coffee and beer all have combination products

Fruit Browning – TOTALLY DIFFERENT

Fruits, vegetables (potatoes, salads…) and even some shellfish, turn brown soon after cutting or just sitting on shelf/counter.

- This is a very different reaction than the Mallaird or caramelization reaction
- Due to cell walls in plant cells reacting with oxygen
- Reaction is called oxidation and catalyzed by an enzyme – tyrosinase aka phenoloxidase