

# What is Caramelization?



Caramel (heated sucrose)

**Caramelization** or **caramelisation** (see spelling differences) is the oxidation of sugar, a process used extensively in cooking for the resulting nutty flavor and brown color. Caramelization is a type of non-enzymatic browning reaction. As the process occurs, volatile chemicals are released producing the characteristic caramel flavor. The reaction involves the removal of water (as steam) and the break down of the sugar. The caramelization reaction depends on the type of sugar. Sucrose and glucose caramelize around 160C (320F) and fructose caramelizes at 110C (230F).

## Caramelization temperatures

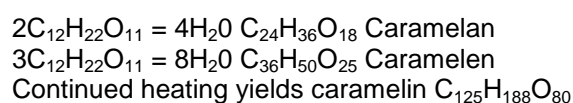
Sugar	Temperature
<a href="#">Fructose</a>	110° C, 230° F
Galactose	160° C, 320° F
<a href="#">Glucose</a>	160° C, 320° F
Maltose	180° C, 356° F
<a href="#">Sucrose</a>	160° C, 320° F

The highest rate of the color development is caused by fructose as caramelization of fructose starts at 110C. Baked goods made from honey or fructose syrup will therefore give a darker color.

Caramelization of sucrose starts with the melting of the sugar at high temperatures (see below) followed by foaming (boiling). Sucrose first decomposes into glucose and fructose. This is followed by a condensation step, in which the individual sugars lose water and react with each other. Hundreds of new aromatic compounds are formed having a range of complex flavors.

In the case of the caramelization of sucrose three main product groups are formed: a dehydration product, caramelan  $C_{12}H_{18}O_9$ ; and two polymers, caramelen  $C_{36}H_{50}O_{25}$  and caramelin. The average molecular formula for caramelin  $C_{125}H_{188}O_{80}$ .

Caramelization Products:



Caramelization continues to be a poorly understood process Here is an overview:

1. equilibration of anomeric and ring forms
2. sucrose inversion to fructose and glucose
3. condensation
4. intramolecular bonding
5. isomerization of aldoses to ketoses
6. dehydration reactions
7. fragmentation reactions
8. unsaturated polymer formation

### Flavors of Caramel:

Diacetyl ( 2,3-butanedione) is an important flavour compound, produced during the first stages of caramelization. Diacetyl is mainly responsible for a buttery or butterscotch flavour.

Esters and lactones which have a sweet rum like flavor.

Furans which have a nutty flavor.

Maltol has a toasty flavor.

If caramelization is allowed to proceed to far the taste of the mixture will become less sweet as the original sugar is destroyed. Eventually the flavor will turn bitter.

NOTE: Caramelization should not be confused with the [Maillard reaction](#), in which reducing sugar reacts with amino acids.



### Caramelized Carrots

Carrots have a higher natural sugar content than all other vegetables with the exception of beets. In the photo above the high sugar content produced a highly caramelized surface. Carrots are high in glucose, fructose and sucrose (depending on the breed of carrot) which promote caramelization. In the case of carrots the reaction actually contains both caramelization products and [Maillard reaction](#) products since vegetables also contain amino acids along with reducing sugars. (Note: sucrose is not a [reducing sugars](#)).

### References:

- [\(1\) Overview of Caramel Colors](#)
- [\(2\) Caramelization](#)

출처: <http://www.scienceofcooking.com/caramelization.htm>