Staling in Baked Goods: Causes and Solutions

What is bread staling?

Bread staling is simply an aging process in which textural characteristics of bread and cakes are negatively affected. The following phenomena are always present during bread staling:

- Bread crumb firmness significantly increases
- Loss of fresh crumb springiness or elasticity over time
- Increased crumbliness
- Crispness of the bread crust decreases
- Bread loaf loses its fragrance, assuming a stale flavor

Bread can be seen as an unstable material once it has been baked. This is due to the chemical composition of the flour used, interactions between ingredients (starch, lipids, gluten proteins), and processing conditions.

What causes staling?

While many theories abound, the mechanisms behind bread staling are mainly linked to the reorganization of starch fractions. Particularly, those of highly branched amylopectin molecules.

This is due to their:

- Retrogradation from the swollen, amorphous, gelatinized state into their native, rigid, crystalline state.
- Water migration from product after cooling and bagging that affects the rate at which staling occurs.
- Further moisture loss in the bagged bread during storage and transport also allows staling to proceed faster.

The breadmaking process, packaging technology and storage conditions can significantly affect staling and how fast it occurs:

- Formulation (use of fat, sugar, enzymes, emulsifiers & hydrocolloids)
- Dough system used in the production process
- Specific volume of the finished product
- Packaging or bagging technology (fully sealed package or twist-tie closure)
- Type of packaging film used (gas permeability, water vapor transmission)
- Thermal treatments of the dough (baking and freezing operations)
- Water evaporation during baking (i.e. bake loss)
- Temperature and relative humidity during storage and transport

STALING & FOOD WASTE

Every year, almost 33% of all food produced for human consumption goes to waste. When looking at totals by weight, bread often tops the list of food waste that could have been avoided. This is even more serious if we take into account the portion of the total human population who do not have proper access to food, both in terms of quality and quantity.[1]

About 15–20% of that total food waste occurs at the household level; meaning food is thrown away once it has reached the household after traveling across the supply chain. Therefore, a larger portion is lost during handling, storage and transport.[1]

Troubleshooting Staling in Breadmaking

Staling is an inevitable phenomena. Bakers can only delay its onset, using available tools to extend shelf-life of bread as long as possible. There are two basic strategies that can extend bread's freshness as well as enhance its appearance; these are formulation and processing methods.

Formulation approaches

- Sugar and fat addition (rich formulations)
- In-situ generation of nonpolar surfactants by use of lipases
- Use of specialty amylases, such as maltogenic alpha-amylase of intermediate thermostability
- Inclusion of water-holding ingredients, such as gums[2]
- Production of aerated bread with high specific volume
- Emulsifiers

Troubleshooting Staling in Breadmaking (cont.)

Processing approaches

- Water is a universal plasticizer, so avoid excessive bake loss that reduces the water levels in bread.

- Balance mold-free shelf life and texture shelf life (higher moisture in the finished product will delay staling but will likely favor mold growth).

- Use of specialized packaging technology—different from the regular twist-tie closure bagging tech seen in high-speed bakeries—will definitely be an edge, limiting moisture loss to its minimum and keep the crumb softer.

- Storage conditions: Storage temperature is also important as bread stales faster at low temperatures, particularly at a range of 0–10°C (32–50°F).

- Freezing bread: Freezing temperatures colder than -15°C (5°F) reduces the rate of chemical reactions and physical transitions to practically zero values.

How to measure staling

- Rheological methods
- Thermal analysis
- Infrared spectroscopy: Fourier transform infrared (FTIR), near infrared (NIR) reflectance, and nuclear magnetic resonance (NMR) spectroscopy
- X-ray crystallography
- Microscopy: Transmitted and polarized light, CLSM and electron
- Sensory/organoleptic tests

A Closer Look at Crumb Softening Enzymes

A more effective approach to reduce crumb firming and to maintain crumb elasticity over time is the use of amylases. Modifying the starch undergoing retrogradation with an amylase slows down the reorganization it undergoes immediately after it comes out of the oven.

Fungal amylase

Alpha-amylase derived from fungal sources tends to be heat sensitive as it begins to denature rapidly at temperatures greater than 57°C (135°F). When the bulk of the starch in bread dough is available for enzyme modification (i.e., when the starch is gelatinized), fungal enzymes will have been inactivated.

Bacterial amylase

Unlike their fungal counterparts, these enzymes remain active well into the baking process. Depending on the internal temperature of the baked product, a portion of the initial dosage of bacterial amylase could still be active when the bread leaves the oven and as it cools. If the bread is kept at room temperature, the enzyme continues to break down starch, although at an extremely slow rate.

This extended activity is particularly problematic. Highly thermostable bacterial amylase is very aggressive and can break down the amylopectin structure, destroying crumb springiness.

Intermediate thermostable bacterial or fungal amylase

Intermediate thermostable maltogenic alpha-amylase obtained either from bacterial or fungal sources has a unique action pattern, leaving the amylopectin's backbone structure intact while generating small sugar molecules from the ends of the starch molecules.

It works optimally in conditions between malt flour and thermostable bacterial amylase by acting on the starch during gelatinization. The combination of temperature profile and action pattern allows bread to remain softer and more resilient for a longer time period.

Is there a way to make my flour tortilla not crack while we roll it after three days of shelf storage?

Flour tortillas are supposed to be rollable throughout their entire shelf-life. If they don't, staling is a large contributor to it. Using a combination of emulsifiers, gums and amylases, would be key to preventing staling of the tortilla. If doing flour tortillas without the addition of any of these three ingredients, the key would be to keep an eye on the baking process. An excessive bake loss will remove the necessary water to make the tortilla more plastic and soft. Crumbliness due to dryness will always limit the rollability of flour tortillas.

My flour is very weak. Which enzyme is best for bread and how much can I use?

If your flour is weak, the first thing to do is seek for flour improvers or dough strengthening enzyme solutions. Low quality flour will always impact product volume. If you end up with a product that is dense and has a very low volume, you will soon experience that staling will be more noticeable. Highly aerated bread with good volume will always feel softer and more springy to the touch.

What if I want bread to be soft and have a gummy mouthfeel at the same time?

This is absolutely possible and enzyme suppliers can meet this particular requirement. Depending on what you want for the finished product, enzyme suppliers can mix different types of amylases (e.g. blending maltogenic amylases of both high and intermediate thermostability) to obtain the desired texture and mouthfeel characteristics that you are looking for.

I am looking for a maltogenic amylase enzyme for bread and rolls. Does it survive the baking process or get fully deactivated by temperature?

The term maltogenic only means that the amylase in question has rather an exo-action when it comes to starch hydrolysis points. This means maltogenic amylase breaks down starch from the non-reducing ends of amylose and amylopectin chains. What is really important when looking for maltogenic amylase is to know the origin (e.g. bacterial or fungal), and the optimum/deactivation temperature ranges. Maltogenic alpha-amylase with intermediate thermostability should be your target.

Most commercial maltogenic amylases for shelf-life extension have an intermediate thermostability, meaning they won't survive typical oven temperatures and are completely destroyed by the baking kill step.

References

1. Food Navigator: Waste bread used to feed microbes for fermented foods: 'The technology is extremely simple', https://www.foodnavigator.com/Article/2020/03/05/Waste-bread-used-to-feed-microbes-for-fermented-foods-The-technology-is-extremely-simple. Accessed 18 July 2020.
2. Sahi, S.S., Little, K., and Ananingsih, V.K. "Quality Control." Bakery Products Science and Technology, 2nd edition, John Wiley & Sons, Ltd, 2014, pp. 502–503.