LALLEMAND
BAKING UPDATE

VOLUME 3/NUMBER 10

Bread Softness

Practical technology from Lallemand Inc.

Starch-Degrading Enzymes

Enzymes can be classified by the reactions they catalyze, the substrates they act on, the products they form, their thermal stability, or their source. One common system is the IUB or E.C. classification, which uses a combination of criteria in a tiered approach. Amylases are classified as E.C. 3.2.1: E.C. 3 for "Hydrolases," E.C. 3.2 for "Hydrolases which are glucosidases," E.C. 3.2.1 for "Glucosidases which hydrolyze O-glycosyl compounds."

Amylases can be further classified on the basis of the anomeric form of their reaction product. D-glucose has two forms or anomers (*alpha-* and *beta-*) depending on the orientation of the H and OH groups around its first carbon atom. The amylose fraction of starch is made up of glucose units connected by *alpha*-1,4 linkages while the amylopectin fraction also contains *alpha*-1,6 linkages at its branch points. Amylases producing hydrolysis products that retain their *alpha-* configuration are classified as *alpha*-amylases. Amylases that invert their hydrolysis products to the *beta-* form are classified as *beta*-amylases. The wheat flour amylase that degrades amylose into maltose and amylopectin into a mixture of maltose and a *beta*-limit dextrin is the best known example of a *beta*-amylase (E.C. 3.2.1.2).

Starch-degrading enzymes can also be classified based on their action pattern as exo-acting, endo-acting, or debranching. Exo-acting, or saccharifying, amylases degrade amylose and amylopectin by successive removal of sugar units from the nonreducing chain ends. Endoacting, or liquefying, amylases degrade amylose and amylopectin by randomly cleaving *alpha*-1,4 linkages throughout the chains. Debranching enzymes degrade amylopectin by cleaving the *alpha*-1,6 linkages at the branch points. *Beta*-amylases and glucoamylases (E.C. 3.2.1.3) remove maltose and glucose

Continued

Improving Crumb Softness

BREAD STALING has a significant economic impact on the baking industry because of the costs for unsalable product, thrift store discounts, more-frequent distribution, and multipurpose production lines. Bakers can improve bread softness and minimize bread staling by optimizing their ingredients, processes, and packaging and by using antistaling agents.

Ingredients and process modifications that improve the softness of the freshly baked bread will also improve the quality of the bread after storage. Ingredients that affect loaf volume and crumb structure, such as fat, water, oxidants, enzymes, gluten, flour, etc., also affect crumb softness. This can be explained from a larger loaf volume resulting in a less dense and therefore softer breadcrumb and from the finer, more regular crumb structure as a result of an optimally developed and functional gluten structure.

A well-developed gluten structure contributes to better crumb resilience and to better water-retaining capacity, resulting in a softer, less crumbly crumb. Therefore, process conditions like mixing and fermentation that affect crumb structure will affect crumb softness. Ingredients and process conditions that increase the moisture content of the breadcrumb (sugar, fibers, water absorption, baking conditions) will also contribute to softness. For this reason it is important to check the oven conditions to avoid excessive moisture loss during baking.

Packaging that prevents moisture loss will keep the crumb softer. Storage temperature is also important because bread stales faster at low [32° to 50°F (0° to 10°C)] temperatures. The more-rapid firming of bread in the winter can be minimized by storing the bread in a warm area prior to shipment and also by preheating the interior of delivery trucks prior to loading.

Emulsifiers (surfactants) are used as antistaling agents, mostly to improve initial crumb softness. They work by complexing with gelatinizing starch, so the best choices are those with a high ACI (Amylose Complexing Index) such as mono- and diglycerides, distilled monoglycerides, polysorbates,

Continued

AMYLASE CHARACTERISTICS

Enzyme/Source	Thermo-Stability	Action Pattern	Crumb Softness	Crumb Resilience
Fungal α-amylase *Aspergillus oryzae*	low	endo	+	++
Fungal glucoamylase *Aspergillus niger*	low	exo		++
Fungal α-amylase *Aspergillus niger*	interm.	endo	++	++ (at low pH)
Cereal α-amylase Malted wheat/barley	interm.	endo	++	++ (protease side activity)
Cereal β-amylase Wheat flour	low	exo (maltogenic)		++++
Bacterial α-amylase *Bacillus subtilis*	high	endo	++++	+
Bacterial α-amylase *Bacillus megaterium*	interm.	endo	+++	++
Bacterial amylase *Pseudomonas saccharophilia*	interm.	exo (maltotetragenic)	+++	++++
Bacterial amylase *Geobacillus stearothermophilus*	interm.	exo (maltogenic)	++++	++++

Improving Crumb Softness *(Continued)*

and sodium stearoyl-2-lactylate (SSL).

Enzymes act on the dough during mixing and proofing to provide uniform crumb structure, increase volume, and improve initial softness. They also act during baking to slow the rate of firming during storage. Timing is critical, because the gluten and starch network in the dough needs to be strong enough to retain the gas produced during proofing, but the same gluten and starch network needs to be weak enough after baking to remain soft.

The primary enzymes used are amylases that break down starch. Proteases that break down gluten during baking can also be used, but they are more difficult to control and can have a negative effect on crumb texture. The thermostability and action pattern of amylases are important for their performance.

Thermostability is crucial because the bulk of the starch in a dough is native starch that can only be modified by enzymes after gelatinization, which occurs during baking at temperatures above 150°F (65°C).

Action pattern is important because it affects the relative effect of the enzyme on softness, resilience, and moistness/gumminess. Endo-acting amylases randomly break down branched starch, which helps prevent it from firming but can also reduce resilience and cause gumminess. Exo-acting amylases break down branched starch from the ends, preventing it from firming while maintaining resilience.

Malt and fungal amylases act on the starch in the dough to delay crust set in the oven. This allows more "oven spring" and increases volume, which helps initial softness. They have an endo action pattern but low thermostability so are inactivated early in the baking process and have little antistaling effect.

Enzymes with high thermostability, such as classical bacterial amylase, improve crumb softness considerably, but tend to give the "wrong" kind of softness, resulting in a gummy bread crumb lacking resilience. So, the action of classical bacterial amylase must be very well controlled to give the right balance of crumb softness and crumb resilience. In practice this is difficult to achieve, because the classical bacterial amylase survives the baking process and is still active in the baked bread. This explains why the use of the classical bacterial amylase as a crumb softener has remained very limited.

Better control is possible with newer types of fungal and bacterial amylases characterized by a so-called intermediate thermostability like the *Bacillus megaterium* amylase and the *Aspergillus niger* acid amylase. Although these enzymes, which are fully inactivated during baking, will give more-consistent results, they still tend to produce a bread crumb lacking resilience.

Softer bread crumb with no loss of resilience requires an amylase with both intermediate thermostability and an exo-acting (maltogenic) action pattern. This explains the superior performance of *Geobacillus stearothermophilus* amylase as a crumb softener that produces softer yet resilient bread crumb without gumminess even at higher dosages.

Starch-degrading Enzymes *(Continued)*

units, respectively, from starch so are classified as exo-amylases. *Alpha*-amylases (E.C. 3.2.1.1) generally degrade starch into dextrins so most are classified as endo-amylases. Pullulanases (E.C. 3.2.1.41) and isoamylases (E.C. 3.2.1.68) are classified as debranching enzymes.

Yet another way of classifying enzymes is by thermostability, or the temperature and conditions at which they are inactivated. Enzymes with the same action pattern can differ greatly in thermostability depending on their source. For baking applications, the critical temperature range is from about 150° to 175°F (65° to 80°C), where starch is gelatinized and subject to hydrolysis. Starch-degrading enzymes that are inactivated quickly at 140°F (60°C) can be classified as low thermostability, those that remain active above 175°F (80°C) can be classified as high thermostability, and those in-between can be classified as intermediate thermostability.

When comparing the effect of various amylolytic enzymes on crumb softness and crumb resilience (see table), it becomes apparent that action pattern and thermostability are the most important characteristics. The maltogenic amylase from *Bacillus stearothermophilus* outperforms the other amylases as a crumb softening agent giving a superior crumb softening effect without causing gumminess or a lack of crumb resilience. This enzyme also has the most desirable combination of exo-action pattern and intermediate thermostability.

Lallemand Crumb Softeners

LALLEMAND Baking Solutions was a pioneer in the use of enzymes to improve crumb softness and today offers a full range of high-performance enzymes and dough conditioners:

- **Essential**® enzyme systems improve initial softness by helping to optimize crumb texture, volume, and processing tolerance.
- The **Essential® ER** range replaces emulsifiers like DATEM and SSL while reducing cost.
- The **Essential® SOFT** range extends shelf life by maintaining softness and resilience.
- The **Essential® CL** range combines oxidizer and emulsifier replacement with shelf-life extension to provide all-in-one clean label solutions.

Formulations are available for all types of dough systems and for a variety of baked goods applications, including:

- Bread
- Buns and rolls
- Pita and flat breads
- Bagels
- Cakes
- Yeast-raised and cake donuts

Lallemand products are backed by a skilled technical support staff that will be happy to assist you in determining which product best suits your process and application.

LALLEMAND
BAKING UPDATE

Lallemand Baking Update is produced by Lallemand Inc. to provide bakers with a source of practical technology for solving problems. You can find the latest issues online at www.lallemandbaking.com.

If you have questions or comments, please contact us at:

LALLEMAND Inc.
1620 Préfontaine
Montréal, QC H1W 2N8 Canada
tel: (800) 840-4047 (514) 522-2133
email: solutions@lallemand.com
www.lallemand.com