LALLEMAND
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Bread Softness

Practical technology from Lallemand Inc., parent of American Yeast Sales, producers and distributors of Eagle® yeast, fresh and instant.
AMERICAN YEAST SALES Eagle fermipan

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 non-reducing chain ends. Endo-acting, 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 units, respectively, from starch so

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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 bread crumb 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 bread crumb (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, and sodium stearoyl-2-lactylate (SSL).

Enzymes are also used as antistaling agents, in particular amylases that break

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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 *Bacillus stearothermophilus*	interm.	exo (maltogenic)	++++	++++

Improving Crumb Softness *(Continued)*

down gelatinizing starch during baking. The heat stability and action patterns of amylases are important parameters for their performance.

Thermostability of amylolytic enzymes 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). Therefore, enzymes with a low thermostability like regular fungal amylase or wheat flour *beta*-amylase cannot improve crumb softness to any great extent.

Enzymes with high thermostability such as regular bacterial amylase improve crumb softness considerably, but tend to give the "wrong" kind of softness, resulting in a gummy bread crumb lacking resilience. For this reason the action of regular bacterial amylase must be very well controlled to give the right balance between crumb softness and crumb resilience. In practice this is difficult to achieve because the regular bacterial amylase survives the baking process and is still active in the baked bread. This explains why the use of the regular 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 without a loss of crumb resilience requires an amylase with both an intermediate thermostability and an exo-acting (maltogenic) action pattern. This explains the superior performance of *Bacillus stearothermophilus* amylase as a crumb softener that produces softer yet resilient bread crumb without gumminess even at higher dosages (see table).

Starch-Degrading Enzymes *(Continued)*

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 supplies a full range of products for improving the crumb softness of bakery products. These products are distributed to the baking industry through Lallemand Distribution and American Yeast Sales and are backed by technical support from experienced bakery technicians.

Essential® SOFT V is an enzyme-based dough conditioner for bread and other yeast-raised products that optimizes loaf volume, crumb texture, initial crumb softness, and extended shelf life. It contains a combination of fungal amylases and a *Bacillus stearothermophilus* bacterial amylase. The fungal amylases improve loaf volume, crumb structure, and softness, while the bacterial amylase provides an additional softness and shelf life benefit. The *Bacillus stearothermophilus* amylase has both an intermediate thermostability and an exo-acting (maltogenic) action pattern so it produces a softer yet resilient crumb without gumminess or the risk of overdosing. Essential® SOFT V gives optimal results when used in combination with normal levels of oxidants and emulsifiers (e.g., 0.25 percent SSL).

Essential® SOFT VI is a less concentrated version of Essential® SOFT V designed for more convenient scaling.

Essential® SOFT II is an enzyme-based dough conditioner for chemically leavened and yeast-raised products. It contains bacterial amylase as the principal crumb softening agent. Essential® SOFT II is used for improving softness of products like cakes, muffins, and brownies, for which crumb resilience is less critical than for voluminous bread products. When Essential® SOFT II is used to improve crumb softness of bread and other yeast-raised products, it is advised to use it in combination with emulsifiers. Essential® SOFT II improves crumb softness and the emulsifiers provide a longer lasting effect.

Essential® SOFT I is an enzyme-based dough conditioner for bread and other yeast-raised products. It contains a lipase enzyme that produces monoglycerides from the naturally occurring lipids in flour and can be used to help replace shortening and emulsifiers.

Essential® SOFT III is an enzyme-based dough conditioner for bread and other yeast-raised products. It contains a fungal amylase with intermediate thermostability and can be used to improve loaf volume, crumb texture, and crumb softness without the risk of overdosing.

Emulsifiers are also available from Lallemand, including sodium stearoyl-2-lactylate and distilled monoglycerides. They can be used alone or in combination with Essential® dough conditioners to improve crumb softness and shelf life.

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Lallemand Baking Update is produced by Lallemand Inc. to provide bakers with a source of practical technology for solving problems. If you would like to be on our mailing list to receive future copies, or if you have questions or comments, please contact us at:

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