The baking and frozen dough market

Functional oxidation for improved frozen dough

by Caroline van Benschop - Product Application Expert Baking Enzymes, DSM Food Specialties

Creating a healthier lifestyle remains of paramount importance to most consumers when choosing food. The impact of population growth and urbanisation is also directing us to source our foods in more sustainable ways and distribute it efficiently to ever growing cities and towns. In the bakery industry, this has led to an increased industrialisation and scale of operations, usually coupled with a decline of the smaller artisanal or craft establishments. However, we still demand the same standards of freshness, diversity and authenticity from the large plant bakeries.

Challenges for the baker have continued up to the present day. Consumers purchase groceries at a wide variety of different retail channels and travel more than ever before. They buy baked goods on the way to and from work and expect to find the products they want at their travel destinations. People desire familiar, healthy, tasty and high quality bakery products wherever they go. The large industrial bakeries need to produce the same quality, if not better, than the local craft store.

With a total annual consumption of 140 million tonnes (MT) per annum, bread is a key component of people's diet. Frozen dough, where the dough is stabilised by freezing until the moment the bread is baked, provides opportunities for the baking industry. For the retailer, it means less waste and more flexibility with respect to changes in demand, thus offering the ability to react fast when restocking shelves in the supermarket. For food service, the advantage is that several small batches of bread can be thawed, proved and baked per day, offering them more choice of fresher breads.

According to Mintel, the frozen dough market has grown by 8.1 percent over the period 2006-2011 and, in some parts of the world, the frozen dough market is growing even more rapidly. The Rabobank estimates that the frozen dough market in China grew from 500million CNY (82 million USD) to 2billion CNY (US$329 million) from 2008 to 2013.

Frozen dough challenges

One of the challenges faced by frozen dough manufactures is that the impact of the freezing step on the quality of the final baked goods. In general, frozen dough gives rise to slower proving and poorer product quality than fresh dough, which can be most noted in a poorer shape, a coarser crumb structure and, most importantly, a lower volume of the baked goods.

One of the reasons of slower proofing and reduced bread volume can be a lower yeast activity during fermentation, as some yeast cells may be damaged during the freezing process and subsequent frozen storage. Another reason for poor product quality can be changes in the gluten structure during the freezing process and sub-zero storage. A good gluten network is essential for the capacity to retain CO^2 during fermentation.

During freezing and storing, two processes can occur that influence the eventual gluten structure. Firstly, the gluten network may be disrupted by ice crystal growth. A damaged network is limited in retaining gas during fermentation, resulting in slower proving, lower bread volumes and a poorer shape and crumb structure. Secondly, during ice crystal growth, the water separates from the gluten and crystalises; which could lead to gluten dehydration.

Dehydrated gluten has a more rigid structure, which adversely affects dough extensibility and elasticity during the proving phase. Although the dehydration process of the gluten network typically takes place within a few days, further damage to the gluten network can be caused during prolonged storage times as a result of further ice crystal growth in the gas cells. During thawing, the water redistributes itself over the dough, but does not properly rehydrate the gluten, leading to a decrease in the gluten network strength.

Generally speaking, this is why less water is added to the dough; as this will limit the amount of free water. However, there should still be enough water in the dough to properly hydrate the gluten and yeast, as this facilitates good mixing and ensures constituent mobility in the system. The effects described above have an adverse effect on the gas retention capabilities during fermentation, and the extent to which they occur during freezing and subsequent thawing; said effects should therefore be kept to an absolute minimum.

Different oxidation systems

Disulfide bridges between gluten proteins are essential for the formation of the gluten network and for the viscoelastic properties of dough. Having an appropriate level of sulfhydryl oxidation is crucial for optimal dough properties.

The functionality of the gluten proteins during bread making can be altered by the incorporation of redox agents. These redox agents can be divided into chemical additives and enzymes. A weak dough can be strengthened by the addition of oxidising agents, whereas a dough made from stronger flour (Canadian or Australian flour, for example) can be made more extensible by the addition of reducing agents, such as glutathione. Examples of chemical oxidants include, among others, ascorbic acid, potassium bromate and asodicarbonamide (ADA). These differ in how quickly they act; ADA is a fast-acting oxidant, bromate is a slow-acting oxidant and ascorbic acid (or more specifically its derivative dehydroascorbic acid) has a more intermediate speed of oxidation.

Another aspect differentiating the oxidants is the effect they have on dough handling. For example, ascorbic acid and, to a greater extent, calcium peroxide will allow the dough to absorb additional water and will impart a dry surface to the dough. Iodate or ADA create a slightly opposite effect and leave the dough more pliable and soft. Each of these oxidants have their own function in a recipe and are not easily inter-changeable.

The use of enzymes as oxidising agents is an attractive alternative because of legislative restrictions on certain chemical oxidants and also in view of the current trend towards more natural and easy to understand ingredients on labels. Examples of such enzymes in bread making include laccase, tyrosinase, hexose oxidase and glucose oxidase, of which glucose oxidase is the most commonly used.

It is generally recognised in the bakery industry that glucose oxidase improves dough handling properties and dough stability during bread making. The glucose oxidases currently available in the market are part of a toolbox to replace chemical oxidisers such as ascorbic acid, due to their ability to act fast, allowing the dough to absorb water and create a dry dough surface.

Using glucose oxidase in the dough process

The use of glucose oxidase during the dough production process is widely recognised within the baking industry. In the presence of oxygen and glucose, glucose oxidase will generate hydrogen peroxide which causes the oxidation of free sulfhydryl groups present in gluten proteins to form disulfide linkages. The extent of cross-linking is highly determined by the rate of hydrogen peroxide.

High production levels of hydrogen peroxide, especially during the mixing phase, might lead to a decrease in the size of the gluten aggregates rather than the formation of an extended network and thus lead to short doughs lacking extensibility.

Introducing a new glucose oxidase

DSM has developed a new glucose oxidase, BakeZyme® Go Pure, originating from Penicillium chrysogenum. Biochemical analyses of BakeZyme® Go Pure have shown that this enzyme exhibits a self-regulating mechanism, unlike glucose oxidase originating from Aspergillus niger. The production of hydrogen peroxide takes place in a controlled manner, avoiding over-oxidising of the gluten network. A possible larger and more extensive gluten network is thus formed, improving the overall strength of the dough. Moreover, it allows for the dough to become more elastic, maintaining its ability to stretch during gas expansion.

In frozen dough processing, this is a particularly beneficial property as the frozen dough process demands the formation of a well-developed and extensible dough at lower temperatures, in order to avoid excessive yeast activity before the freezing process starts. Moreover, the controlled formation of hydrogen peroxide reduces the risk of off-flavour formation.

The self-regulating mechanism of BakeZyme® Go Pure makes it also suitable for short-time and high-shear bread making processes, such as Chorleywood Bread Processes.

When using BakeZyme® Go Pure in the dough, it will remain soft and pliable, improving the stability during fermentation. BakeZyme® Go Pure is potentially also an effective alternative to the use of chemical oxidisers such as ADA. Bakery tests have shown that the use of BakeZyme® Go Pure results in highly similar dough characteristics compared to dough obtained by use of ADA. The final bread where BakeZyme® Go Pure was used in the dough shows a good shape, volume, and in particular a fine crumb structure.

Conclusion

The effect of glucose oxidase on dough properties is due to the production of hydrogen peroxide that induces protein cross-linking via disulfide bridges. The extent of cross-linking in dough depends on the production rate and concentration of hydrogen peroxide. BakeZyme® Go Pure is a new glucose oxidase with a unique self-regulating mechanism that avoids excessive hydrogen peroxide formation.

This will create opportunities for the use of glucose oxidase in frozen dough applications with reduced risk of off-flavor formation, in short-time and high-shear bread making processes (such as Chorleywood Bread Processes), and as a tool for replacing chemical oxidisers (such as ADA or Bromate).

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