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Bread improvers – action and application

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The use of improvers in the production of baked goods is common practice today. It is also part of the technological effort to produce baked goods from wheat and rye flour that have high sensory, practical and nutritional value. Besides the use of machines for dough and batter make-up, processing and baking, improvers are used specifically to improve production methods and the quality of bakery products.

According to the definition laid down in the German Guidelines for Bread and Small Baked Items, improvers are mixtures of food including additives intended to facilitate or simplify the production of baked goods, to compensate for changes in processing properties due to fluctuations in raw materials and to influence the quality of baked goods.

In Austria, improvers are similarly defined by the BMSG (Federal Ministry for Social Security, Generations and Consumer Protection) in decree 31.901/25-IX/B/12/01 of July 3, 2001.

"Improvers" are preparations intended to simplify the production of baked goods, to compensate changes in processing properties due to fluctuations in raw materials and to improve the quality of bakery products. They are made from food (cereal products such as starch, malt, ..., different sugars, dairy products such as powdered milk, soy flour, ...) with or without additives (preservatives, fruit acids, phosphates, thickening agents, ...), depending on the relevant application. The substances used for improvers are often also components found in the food product that is being made with these improvers.

Improvers can be composed differently depending on the product to be used in or on the intended production method.

They belong to either one of the following groups:

1. Improvers for small yeast-raised items (rolls)
2. Improvers for bread with more than 10 % rye flour content (acidifier)
3. Improvers for toast bread and wheat bread
4. Improvers for yeast-raised fine bakery wares
5. Improvers for retarded and interrupted proofing
6. Improvers for prolonged shelf life (staling retarder)
7. Improver for production of pound and sponge cakes (batter enhancing agent)

Improvers have been used for more than 100 years to support the full development of the bread flour properties and to balance the natural differences in baking behaviour. But they became of real importance when the production of baked goods was streamlined and the quality was improved and standardised.

Despite their purpose of being used in the production of baked goods, the main task of wheat and rye grains is actually to produce a new plant under optimum conditions. The technological baking properties of milled grain products will develop only after the addition of liquid (water, milk), leavening agent (yeast, chemical baking powders) and other substances (salt, improvers) and through technical preparation measures mainly by introducing mechanical and thermal energy during the production process (mixing, kneading, whipping, sheeting, proofing, baking).

Production processes for baked goods all follow the same order:

- Mixing of milled grain products with liquid and other raw materials
- Preparation of dough or batter by kneading, mixing or whipping
- Leavening of dough or batter by gases
- Thermal conversion of the dough or batter into a solid baked good which can be cut, coated and chewed after cooling.

Only milled grain products from wheat and rye can be used to make products according to the above scheme. Milled products from other types of cereal such as rice, barley, oat or corn will not yield proper dough when combined with liquid. This results in products with a low increase in volume, hardly any browning and which, in addition, are hard to cut, spread and chew. On the other hand, milled wheat and rye products in combination with liquid will yield visco-elastic doughs which retain the gas from the yeast fermentation (CO_2) in the form of tiny bubbles. In wheat dough, the so-called gluten is responsible for that. This protein absorbs water and forms an extensible and elastic membrane which encloses the gas bubbles. In rye doughs, the gas is retained due to the high viscosity of swollen gum-like substances (pentosanes) present in the dough. However, the gas permeability of the mass surrounding the gas bubbles is higher in rye dough than in wheat dough. Therefore, rye-containing baked goods have a lower specific volume than wheat dough products.

In recent years, the technology applied to the production of baked goods has changed significantly. Machines have taken over the manual labour not only in industrial bakeries but also in small craft bakeries. New methods for the efficient production of baked goods require a specific quality of doughs and batters. In addition to that, the consumer also demands high quality. The producer of baked goods can only be commercially successful if he meets those requirements.

Effect of milled wheat and rye components in the production of baked goods

In wheat flour products the protein gluten is mainly responsible for the formation of dough. The amount of gluten, its water absorption capacity as well as its elasticity and extensibility define the processing properties of the dough. Gluten encloses the gas-containing pores in the dough and is thus responsible for the gas retention capacity of the dough and therefore for the volume of the baked good. The quality of the gluten dictates how much gas is retained in the dough.

The main component in flour is starch which is present as lentil-shaped granules. During the baking process, starch swells and partly gelatinises by absorption of the water previously bound to gluten or pentosanes during dough preparation. The swollen starch granules form the crumb structure in the finished baked good (Figure 1). A small portion of the starch granules will be mechanically damaged during milling of the grain. The damaged starch will absorb a greater amount of liquid during dough preparation and can be attacked by amylases.

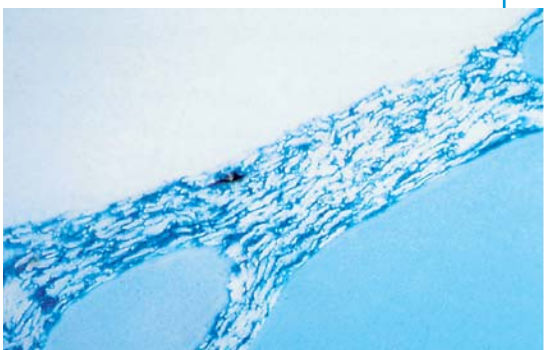

Figure 1:
Microstructure of the crumb.
The light particles are starch granules.

Enzymes are other ingredients important for the baking process. They are located in the outer layer of the grain kernel. Amylases degrade starch to dextrins and then further to fermentable sugars. An excess of alpha-amylase activity in the dough may result in increased starch degradation during the baking process which impairs the crumb formation. This results in an inelastic, sticky crumb. An increased alphaamylase activity can be observed if the grain kernel is damaged by pre-harvest sprouting. This can happen if the ripe kernel takes up water during instances of prolonged rainfall. In particular, rye is susceptible to premature sprouting due to the short dormancy and because the kernels are not completely protected by the husk. This phenomenon is called sprout damage.

Influence of improvers on the baking properties of milled grain products

White wheat flours, used for production of small bakery items, contain only low levels of alpha-amylase because the enzymes is located beneath the hull of the grain which is removed during milling. In the 19th century it was established that the inclusion of flours made from sprout-damaged grains into wheat doughs increased the volume of the baked goods. Some years later, flour from artificially sprouted grains (malt) was used as source of amylase. Today microbial amylase preparations are used as well as malt flour.

Amylases have two important effects on the volume of wheat based bakery items. During the dough phase, amylases partly degrade the damaged starch to fermentable sugars. These, in turn, will be converted into alcohol and carbon dioxide by the yeast and ultimately contribute to the leavening of the dough. The main effect of the alphaamylases, however, takes place during the baking process when the gas bubbles in the dough expand because of the temperature increase (oven spring). This thermal expansion is counteracted by the increasing viscosity of the starch which is simultaneously absorbing water, swelling and partially gelatinising. Selective use of amylases can decrease the viscosity of the starch enabling greater expansion of the gas bubble at the start of the baking process.

Amylases also have an effect on the browning of the crust (bloom). Dextrins and sugars formed during the enzymatic degradation of starch give rise to the formation of a brown colour during baking and the typical bread flavour develops as a result of the reaction between these ingredients and other dough components.

Finally, the starch quality also influences the staling of baked goods. With selective use of amylases, the starch structure can be altered and the shelf life of the baked goods prolonged.

Flour also contains water-insoluble hemicelluloses originating from the walls of the grain cell. By adding **xylanase** these materials can be converted into soluble, gumlike substances which bind water resulting in an increase in dough strength as well as improved dough processability. The risk of dough sticking to machine parts and causing production problems can be minimised in this way. The absorbed water migrates into the starch during the baking process causing a decrease in viscosity and resulting in an improved oven spring and higher volume for the baked goods.

Protein degrading enzymes **(proteases)** are used for improving the processing properties of doughs made with flours containing strong gluten with low elasticity.

Lipoxigenases oxidise lipids present in the dough. They are added as part of an enzyme-active (I. e. not heat processed) soya flour and are used for brightening the crumb (through oxidation of yellow carotinoids) of toast bread.

Emulsifiers are other ingredients found in improvers. Gluten, important for the technological baking properties of wheat flour, contains certain surface-active lipids (emulsifiers) originating from the cell membranes of the wheat kernel (galactosylmono- and -diglycerides) and these contribute to the functional properties of gluten. Dough properties can be further improved by the addition of specific emulsifiers. **Lecithin, diacetyl tartaric acid esters of mono- and diglycerides** as well as **stearoyl lactylate** are all used in improvers. These emulsifiers improve the gas impermeability of the membrane that encloses the gas bubbles. This makes the dough less susceptible to mechanical stress during dividing, moulding and handling. Proofing stability as well as oven spring will also increase.

Monoglycerides of fatty acids and starch will form so-called "inclusion compounds" which prevent the recrystallisation of starch (retrogradation) in the finished baked good. Retrogradation being the main cause of staling.

Hydrocolloids such as **pregelatinised cereal flours** and starches as well as **guar gum** and **soya flour** can also be used to improve the hydration capacity of doughs. These substances take up water during dough preparation making the doughs much drier and more easily processed. Besides that, the increased moisture contributes to optimum starch gelatinisation which, in turn, improves the freshkeeping properties.

Other components in improvers are **ascorbic acid** and **cysteine**. After enzymatic conversion of ascorbic acid into dehydroascorbic acid, this substance acts as an oxidising agent and improves gluten quality and dough stability. The amino acid, cysteine, also reacts with the gluten, but by softening the dough and making them smooth and easy to process.

New processing methods in the bakeries require tailor-made improvers. Interruption and retardation of the fermentation processes are employed in order to utilise times of low work load in the afternoon. They allow doughs to be produced in advance because the processing steps, the proofing and the baking can all be handled separately by intermediate cooling or freezing of the dough pieces. The stress that the dough pieces experience with these methods is balanced mainly by addition of **acidic phosphates** and ascorbic acid.

Figure 2.1: Without acid, very weak crumb, extremely inelastic, not chewable, shape of bread too flat

Figure 2.2: Optimum amount of acid, perfect crumb, typical shape for a bread

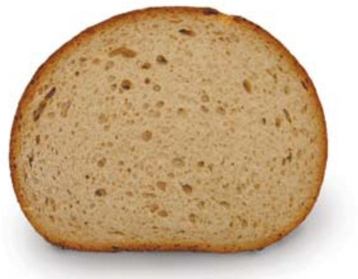

Figure 2.3: Too much acid, firm crumb, shape of bread too round

Up to this point, it is mainly improvers for wheat doughs that have been discussed and now the focus will shift to **rye doughs**. When producing rye doughs from mainly flour, water and yeast, the resulting breads have a more or less inelastic crumb, they are sticky, hard to cut and difficult to spread. Only the addition of acid to the dough results in breads that do not have these shortcomings (Fig. 2) which is why, from time immemorial rye doughs have always been acidified. In earlier times the rye doughs were just left to sit until the lactic acid bacteria, naturally present in the dough, had acidified the dough. Later on, sour dough processes were developed in which lactic and acetic acids were specifically generated. For quite some time now, acidifiers have been used for the production of rye-containing breads. The acidifiers mainly consist of **lactic**, **acetic** or **citric acids** or **acidic phosphates**. The acids cause a reduction in pH in the dough which inhibits the action of alpha-amylases. If a rye dough is not acidified, the rye starch is degraded during the baking process into dextrins which can not fully bind the water in the dough resulting in an inelastic bread crumb. Use of dough acidifiers enables bread to be produced according to the so-called “direct dough” preparation method. Here the baker does not need to make a sponge (sour) dough. For greater tolerance, sour doughs are often used in conjunction with dough acidifiers in what is called a combined dough preparation method.

Staling of wheat bread is often experienced as a firming of the bread crumb during storage. This process can be retarded by the inclusion of monoglycerides of fatty acids, stearoyllactylate and/or water-binding/swelling agents such as guar gum or locust bean gum. (Freshkeeping agents).

Improvers are also used in production of yeast-raised or chemically leavened fine bakery wares. In yeast-raised **fine bakery wares**, the same additives can be used as for wheat bread doughs because the same effects can be achieved. In chemically leavened fine bakery wares, however, improvers are mainly an aid to facilitate the production of the dough/batter. For example, to produce sponge cake by the traditional method, the warm-cold whipping method must be applied to yield a leavened product, whereas the use of so-called **whipping agents** allows whipping of the batter by an all-in-process. Emulsifiers such as hydrated **monglycerides or diglycerols esters of fatty acids** are responsible for air incorporation, because they are able to uniformly distribute the air introduced into the batter during whipping and to stabilize the resulting gas bubbles.

Figure 3:
All these baked goods
were made using improvers.

Application of improvers

Improvers are generally used at an amount of no more than 10 % calculated on flour. Depending on the purpose, they contain an optimum amount of components (see table). They are commercially available as powder, in granular form, as liquid or as a paste.

Composition of improvers

Guideline quantities of substances used to improve the baking of products made using milled wheat or rye expressed as a per cent, of the dough weight	
Hydrocolloids (pregelatinised flour, guar gum, soya flour)	approx. 1 %
Lecithin	0.1 – 0.3 %
Diacetyl tartaric ester of mono- and diglycerides (DAWE, DATEM)	0.2 %
Monoglycerides of fatty acids, Stearoyl lactylate	0.2 %
Ascorbic acid	100 – 200 mg/kg (ppm)
Cysteine	50 mg/kg (ppm)
Acids (citric, lactic, acetic acid)	1 %
Sugars (sucrose, glucose, malt extract)	1 %

Improvers are multi-functional products. Their ingredients interact with each other and are composed in such a way so as to comply with the respective requirements regarding type of flour and type of baked good, baking technology applied and desired quality of baked good. No individual substance can meet all the desired requirements alone. The following table provides an overview of the effects of individual components in the various steps involved in the preparation of dough and baked goods. Substances used to optimise the properties during the dough stage are not necessarily the best choice for optimising the proofing stage. For this phase of the production process, other ingredients are better suited which is why improvers are composed of several baking active substances which each have an individual effect at every subsequent stage of the baking production process.

Effect of improver components on the production of baked goods

Optimisation of dough properties

Optimisation of the fermentation process

- Gas formation
- Proofing stability and oven spring
- Control of proofing time
  (retardation and interruption of proofing time)

Improvement of baked goods properties

- Colour, flavour, crumb quality
- Freshkeeping / Shelf-life

Simplified preparation of doughs and batters

- Ascorbic acid
- Hydrocolloids, pregelatinised flours, vital gluten
- Enzymes
- Soya flours, soya protein
- Emulsifiers

- Sugars, malt flour, malt extract

- Emulsifiers, enzymes
- Fats

- Acidic phosphates
- Enzymes
- Ascorbic acid
- Hydrocolloids
- Vital gluten

- Sugar, malt preparations, dairy products
- Enzymes, soya flour
- Acids

- Hydrocolloids, pregelatinised flour
- Mono- and diglycerides of fatty acids, stearoyl lactylate
- Enzymes, fats

- Mono- and diglycerides of fatty acids
- Polyglycerol ester of fatty acids, propylene glycol ester of edible fatty acids

The fact that no individual substance is able to fulfil all the tasks by itself is clearly demonstrated in the example of the effects that improver components have on the volume of small bakery items made from wheat dough (Figure 4).

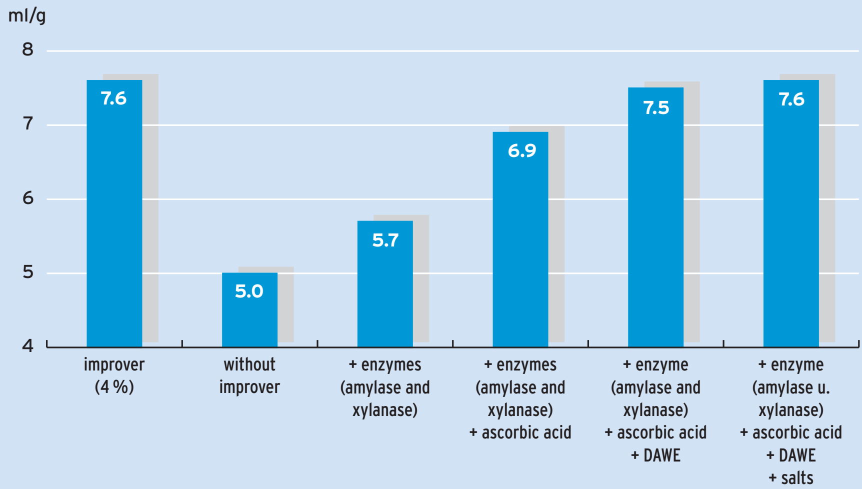

Figure 4: Influence of improver components on the specific volume of small baked goods made from wheat dough (different kinds of rolls)

Improvers have become an essential component in the recipes for baked goods. This will not change in the future because of the strong influence and important role that milled grain products, as major recipe components, will play in further developments within the baking technology sector. Here, cereal breeders (with their aim to genetically influence the chemical composition of grain kernels), farmers (who try to improve the baking properties through cultivation measures), millers (who endeavour to produce suitable flours from different grains) and manufacturers of improvers (who develop optimum products to suit the wide variety of different baked goods and production methods), will all work hand in hand.

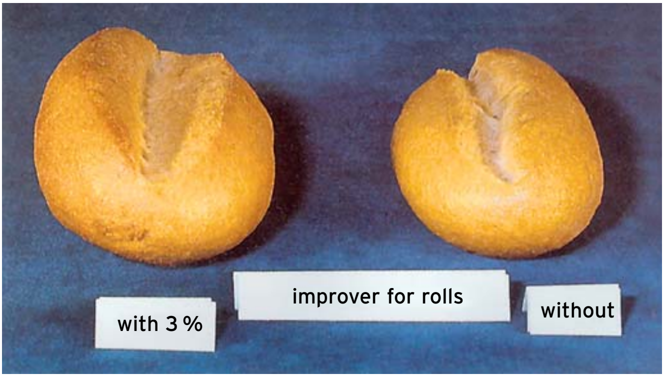

Figure 5:
Rolls with and without improver