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Natural improvers for bakery technology

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Background

The bakery improvers are substances or ingredients that are used in baking in very small quantities and that positively influence the quality of the finished product and its freshness. They include additives and technological aids [2].

In baking, improvers are used for the following purposes: i) development of gluten and organization of the gluten network; ii) optimization of yeast activity; iii) improving the processing of the dough; iv) diversification of the assortment range.

The bakery improvers can be classified into: i) chemicals; ii) enzymatic products; iii) emulsifiers; iv) other compounds.

From the point of view of their actions in the dough, the improvers help to improve the biochemical properties of the dough, as well as the behavior of the dough in general during the technological process. They lead to higher quality products in terms of core structure, shell color, appearance, volume, freshness and aroma.

Keywords: bakery technology, natural improvers. gluten, emulsifiers, enzymes

A. Natural gluten agents

Gluten oxidizing agents make connections between the various filaments in a cluster, thus reducing their mobility from each other. The resulting is firmer dough, this effect being associated with reducing the extensibility of gluten and increasing its elastic strength. The end result for the baker will be to improve the strength of the dough, which means that the dough can be machined, has an increased gas holding capacity and better development when baking [3].

The major proteins in bread, gliadin and glutenin, are found in the form of folded chains, the structure of which is stabilized by either bisulfite bridges or intramolecular bonds (figure 1). The so-called -SH groups, called sulfhydryl, appear in the protein molecules in the flour. If the sulfur atom is bonded to a hydrogen atom, the bisulfite bridges -S-S- cannot form.

Oxidants act on sulfhydryl -SH groups by "cutting" the hydrogen atom so that the sulfur atom remains free and can bind to another sulfur atom to form -SS- bonds, ie bisulfite bridges that act as to strengthen the gluten network.

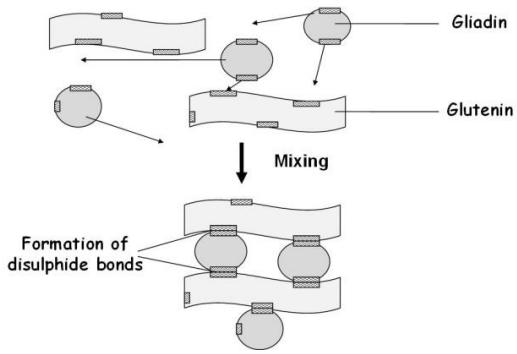

Figure 1. Gluten structure

When kneading, these protein chains stretch and break the relatively weak bonds. During the relaxation of the dough, the bisulfite bridges can be recreated either within the molecules (as they were originally) or between different molecules (intermolecular). When intermolecular bonds occur, the resulting structure (gluten) is much stronger than individual molecules [25].

Ascorbic acid (vitamin C) is the most important oxidizing agent, the use of which is not subject to health restrictions. The proportion in which the addition of ascorbic acid is used varies depending

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on the quality and sort of flour, being usually between 20 and 60 mg/kg flour, and can reach, in some cases, over 200 mg/kg. The following doses are generally recommended:

- poor quality flour: 20-25 mg/kg for white flour, 30-60 mg/kg for semi-white flour and 40-50 mg/kg for black flour;
- medium quality flour: 30-40 mg/kg for white flour, 30-50- mg/kg for semi-white flour and 40-50 mg/kg for black flour;
- high quality flour: 20, 30 and 40 mg/kg respectively [3].

In the case of high-quality gluten-free flour, the addition of ascorbic acid is not necessary, as the gluten becomes too short, brittle and crumbly.

An important factor in the use of ascorbic acid is the temperature of the dough, which must be 24-26^{0}C. It seems that in this temperature range optimal conditions are created for the action of ascorbic acid. Negative effects were found at temperatures above 30°C.

Reducing agents have the opposite effect to oxidants. They break the bisulfite bonds (-S-S-) between protein molecules, weakening their structure. Because the intramolecular bonds are attacked faster, the protein molecules break down easily and the dough is less kneaded. This is especially desirable when making biscuits, or they can be used in combination with a slow-acting oxidant to reduce the kneading time of the bread dough.

B.Natural emulsifier

Emulsifiers are surfactants that have the role of lowering the surface tension at the interface separating two immiscible liquids, allowing a fine dispersion of each other.

The lipids in the flour, although they represent about 2% of the mass of the flour, positively or negatively influence the properties of the dough and therefore also the qualities of the finished product-bread. It has been found that a low lipid content leads to a decrease in volume. Lipid binding can be achieved by starch or protein molecules. By linking starch and protein lipids, lipid-starch and lipid-protein complexes are formed, which have a special importance in baking [2].

Starchy lipids are important in the aging process of bread, not influencing the properties of the dough, while protein-related lipids play an important role in baking.

By adding the emulsifier, the lipid-protein interaction is improved and contributes to: i) increasing the extensibility of the dough; ii) dough tolerance to kneading; iii) improving the hydration of the dough; iv) increasing gas retention.

These dough improvements affect the fragility, even and finer porosity, lighter core, velvety, larger volume, larger texture and longer shelf life.

Monoglycerides are most commonly used in the manufacture of bakery products, the addition of these emulsifiers leading to products with an increased volume, a thinner shell, a finer core, with thin porous walls and a lighter color. At the same time, the products keep their freshness longer. It was found that the addition of glycerin monosterate to the dough preparation, in a proportion of 0.1-0.5% compared to flour, increases the volume of bread by 10-20%, the core becomes much more elastic, whiter with finer porosity and the duration of maintaining freshness increases. It is preferable to use monoglycerides which have a monostearate concentration of 70-90% [2].

Phosphatides (phospholipids), the most representative of which is lecithin, are used in baking due to their ability to form so-called "lyophilic colloids". The ameliorating action of lecithin on dough and bread is due to its high emulsifying capacity, forming monomolecular layers on the surface of flour particles, which fulfill two roles: it regulates the absorption of water by flour proteins during dough formation, as well as the evaporation of starch water during baking process.

The complex enhancer is a mixture most often made up of: emulsifier, gluten, oxidizing agent, enzymatic component, support and biochemical release agent.

Many studies have revealed that vegetable oil improves textural properties characteristics and organoleptic quality of bread [7, 32]. Wu and colab. 2022 [35] highlighted that, *L. lactis* and corn oil used for sourdough fermentation were favorable to the accumulation of most alcohols, while corn oil addition in sourdough had a positive effect on the concentrations of aldehydes, ketones, and furans. In particular, the bread produced by sourdough fermented with corn oil and lipase was preferred by the consumer [36].

Soybean phospholipids and their enzymatic hydrolysates are commonly used emulsifiers which helped improve the bread volume and reduce the crumb hardness and staling rate successfully [37]. Soybeans have the highest phospholipid content than any other plant sources, accounting for 1.6%–2.0% of the whole bean [28].

Encapsulated flaxseed oil, garlic oil, and hybrid microcapsules has impacts on oxidative stability and quality characteristics (color, texture, and sensory) of bread [23].

The use of **oleogels** for replacing solid fats is a hot topic in the food industry. The use of candelilla wax/canola oil oleogel, and the evaluation of its effect on starch digestibility and texture of wheat sponge cake bread was studied by Alvarez-Ramirez J. and colab. in 2020. The results shown that oleogel reduced the viscoelastic properties and decreased cakes hardness, but increased cake specific volume. Oleogel incorporation had a positive effect on the in vitro starch digestibility; the results showed that the use of oleogel for the preparation of sponge cake imposes a trade-off problem between improving the textural properties or increasing starch digestibility [4].

The potentialities of monoglyceride organogel and hydrogel containing sunflower oil in replacing palm oil were studied in sweet breads [10, 22]. The effects were determined by assessing bread specific volume, moisture, firmness, crumb grain, and proton density by magnetic resonance imaging. It was observed less leavened and firmer bread with inhomogeneous lipid distribution. This behavior may by associate with the monoglycerides engaged in oil networking and so, they were less available to interact with other ingredients and exert softening and anti-staling activities [10].

Palm oil was found to have a significant effect on the formation of resistant starch, while sourdough fermentation of rye bread have a greater impact on resistant starch formation than bulk fermentation of wheat and wheat blend breads [9].

The effect of seven improvers on dough rheology and bread specific volume was evaluated by Parenti O. and colab. in 2020 [27]. The results show that all of the improvers affected the farinographic parameters. Bread specific volume was significantly improved by sucrose, extra virgin olive oil and ice. Dough stability and dough weakening, bread specific volume, crumb specific volume and hardness were significantly improved by 2% sucrose and 3% extra virgin olive oil [27].

C. Enzymatic natural products

The use of enzymes in bakery products has increased in recent years as consumers demand for natural ingredients. Various types of enzymes can be used as alternatives to chemical improving agents. Bakery products labeled with word “enzymes” are more attractive for the consumers, because many consumers perceive as natural and clean label compared to other ingredients with chemical name [31].

Generally, three types of enzymes are used in baking: i) amylases that convert starch into sugar; ii) proteases that break down protein molecules; iii) lipoxygenases that whitens flour and strengthens gluten.

Amylase is naturally present in sprouted wheat flour or malt flour. Today, amylase is normally produced by fungal or bacterial fermentation. It is added to the dough where it converts some of the starch present in the flour into sugars that can be assimilated by yeast, so that a larger volume of fermentation gases is produced. Amylases also delay the gelatinization of starch during baking, so bread can grow longer in the oven. Both actions result in increased bread volume [3]. α-Amylase increased loaf volume and decrease the crumb hardness of both white and whole wheat bread [5].

Frequently are used Fungus amylolytic preparations obtained from *Aspergillus oryzae* and *Aspergillus awamori*, rarely proteolytic preparations. Fungal enzymatic preparations facilitate the fermentation of semi-finished products, thus contributing to a shortening of the manufacturing cycle and in the oven in the first part of baking (until the core reaches 70-75°C), it acts energetically on the gelled starch. As a result, the bread volume is higher, the taste is better, and the freshness is maintained for a longer time (due to the increased sugar content).

The effect of amilolytic preparations is based on the modification of starch by the α-amylases it contains, influencing the saccharification and liquefaction of the gel, which leads to an increase in the amount of directly reducing sugars in the dough. The best results are obtained with bread with 1-2% sugar. The proportion of amylolytic addition is determined by baking samples, depending on the quality of the flour.

Proteases are added very carefully in certain doses. These have the effect of irreversibly reducing gluten and are therefore used to treat very strong flours. They are not commonly used in Europe, in North America they are used to some extent because the flours have a high protein content and the quality of the protein is superior.

Lipoxygenase has the role of oxidizing pigments that occur naturally in flour, resulting whiter bread. It also has the role of strengthening the gluten network similar to ADA or ascorbic acid.

The use of malt flour in whole wheat bread action as enzyme supplement because it is rich in α-amylase, and it also contains maltose, proteins, minerals and flavor compounds [8]. The effect of malt flour depends on flour quality. Previous studies highlighted that malt flour provides only marginal improvement to whole wheat bread, and other improvers may be needed in addition to the malt in order to improve the quality of products [18, 19].

Phytase reduces the phytate content in whole grain products and for this reason has nutritional benefits. It may also improve the loaf volume and softness of whole wheat bread [16, 29, 30].

The positive effects of phytase are explained by an activation of endogenous α-amylase in flour. The increase of loaf volume was observed over a range of 25–2500 μL phytase/100 g flour, while crumb firmness decreased with increasing phytase addition, with a maximum decrease of 28% [17].

The introduction of enzymes in the manufacture of bread is done according to the proposed purpose. The type and dose of enzyme is determined by the baking sample.

D. Other ingredients as natural bakery improveers

Different ingredients with specific effects help to obtain various products by giving a certain characteristic. These types of ingredients include **bean flour and soy flour**, the use of which leads to a whiter core of the products. This effect is associated with the oxidation of fats, especially unsaturated lipids in wheat flour.

Inactive malted flour is obtained by controlled germination of wheat and then drying and frying of the malt. Its use determines the intensification of the color of the bread core and gives it a special aroma.

Fermented, dehydrated flours are used in special products. These flours have no fermentative capacity. The advantage of their use is that they improve the aroma, give the finished product specific flavors of fermented products, as well as a certain degree of acidity depending on the type of fermented flour. Sourdough fermentation using functional lactic acid bacteria and yeast as starter cultures is useful in improving the structure and nutrient of sorghum-based gluten-free breads [24].

Sourdough is a mixture of flour and water fermented by lactic acid bacteria (LAB) and yeast used in bread production for dough leavening and acidification in order to improves the technological features regarding texture, shelf life, and nutritional properties in bread [6, 26]. LAB can generate aldehydes, alcohols, esters and ketones contributing to the flavor of sourdough and influencing the bread quality by the activity of peptide hydrolysis, extracellular polysaccharide production, and antibacterial ability [15].

Lactic acid bacteria (LAB) and corn oil in presence of lipase were used for sourdough fermentation. The results showed that LAB fermentation was favorable to the accumulation of most alcohols, while corn oil addition had a positive effect on the concentrations of aldehydes, ketones, and furans. Also, the bread produced by sourdough fermented with corn oil by LAB and lipase was preferred by the consumer panel [22].

Vital wheat gluten is a very important ingredient in whole wheat bread formulations [14]. Supplementation with vital gluten is necessary in whole wheat formulations because bran and germ dilute the amount of gluten in the flour. The addition of vital gluten increases dough water absorption, extensibility, resistance to extension, dough energy and elasticity and improve the gas retention [8, 21]. A 2% addition of vital gluten significantly increased the loaf volume of whole wheat bread [20].

Legumes flour may be added to whole grain bread in order to improve the nutritional quality of the product, but also some technological attributes.

Enzyme-active soy flour (contains lipoxidase), has a whitening effect on wheat flour, improving the flavor and color of bread. Soy flour has a higher water retention and binding capacity and is needed to increase by 1% the amount of water to obtain the normal consistency of dough, for each percentage of

soy flour added [1]. The addition of soy flour to the dough contributes to the gelatinization of the starch, the coagulation of proteins and other physical changes in the preparation of the dough. Enzyme-active soy flour was used as a source of lipoxygenase to improve whole wheat bread [21].

The technological features of bread with 20% of **resistant starch** (RS) and 3% of **garlic** (G) and with both ingredients together (RS + G) were analyzed in a study performed by Correa M.J. and colab. in 2021. The reported results highlighted a decrease in specific volume and crust color on RS bread and an increase of both parameters by garlic addition. Resistant starch led to harder crumbs, while garlic led to softer ones. The structure of fresh crumbs with garlic was more elastic and presented the crunchiest crust. This work shows that combining garlic and resistant starch as ingredients, a functional baked product of good quality and nutritionally improved can be obtained [13].

The inclusion of different amount of whole **quinoa flour** in wheat breads developed nutritionally fortified breads with both slower starch digestibility and desirable textural attributes [31, 33].

The addition of **bee pollen** in order to increase the technological features such as volume, textural properties of crumb, crust and crumb color, crumb cell uniformity and crumb grain structure of bread was studied by Conte P. and colab. in 2018. The breads white pollen showed a slower firming kinetic and were softer compared to the control bread. Addition of 3% and 5% bee pollen leads to improves the overall acceptability of breads. However, at the highest level of pollen, some detrimental effects (especially in terms of crumb texture and staling kinetic) were observed [12].

The gluten modification using different treatment method in order to increase the structure of wheat gluten was investigated in previous studies. **Rice bran** (RB) treatment improved the viscoelastic properties and antioxidant activities of modified gluten. Additionally, the modified gluten showed a higher percentage of branched chain amino acids compared to control gluten. RB treatment achieved these effect by reaction between amino (-NH2) groups of lysine of gluten proteins and RB polyphenols thereby strengthening its network structure.

This study demonstrates that RB treatment modifies the characterization of gluten, and this approach reduces the cost of producing modified gluten and promotes the utilization of RB [34].

The possibility to use **grape seed power (**GSP) as improver in the bakery industry was reported [11]. The reheological properties of wheat flour with GSP, the textural properties of the dough, and thermal properties of the gluten were determined. Chen Sheng-Xiong et al., 2021 studied the effects of the addition of 1%, 3%, and 5% grape seed power (GSP) on the physicochemical and structural properties (free sulfhydryl content, surface hydrophobic region, and secondary structure) of wheat gluten protein. The results shown that 1% GSP leads to the aggregation of gluten proteins by promoting hydrophobic interactions and hydrogen bonding, while 3% and 5% GSP addition disrupted the disulfide bonds between gluten protein and formed macromolecular aggregates linked to gluten proteins through non-covalent bonds and hydrophobic interactions, which prevented the formation of the gluten protein reticulation structure [11].

4. Conclusions

The interest of processors in the bakery industry is increasingly focused on obtaining natural bakery products without chemical additives in the composition. The baking industry challenges are to improve the dough properties, loaf volume, texture, sensory, and shelf-life of bakery products, to increase both production efficiency and consumer acceptance using natural ingredients.

Some examples of improving the quality of bakery products were presented in this study, but this field is open to new research in the future and finding new optimization solutions based on natural improvers for bakery industry.

Compliance with Ethics Requirements. Authors declare that they respect the journal's ethics requirements. Authors declare that they have no conflict of interest and all procedures involving human or animal subjects (if exist) respect the specific regulation and standards.

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