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The Challenges in Frozen Dough: High Resolution Analysis Collaboration

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Since the last decade, the frozen dough production of various bakery products has increased; however, the damages caused by the freezing are still a limiting factor for the expansion of this market. The use of additives, other ingredients and new freezing techniques have been used to reduce these damages; nevertheless, they have a great economic impact on the process, making the product less accessible to the majority of the population.

Traditional fresh bread has a short shelf-life of two to five days due to staling [1]. In order to increase the convenience of having fresh bread available at any time of the day, the frozen dough technology has been developed and investigated [2].

In application, both consumers and factories expect that the foods processed with frozen dough have satisfactory quality and sensory characteristics compared to those with fresh dough. Although the industrial-scale frozen dough has developed rapidly, there are still some problems occurring in its preparation, storage, and transportation. The excessive formation of the gluten network during dough preparation and the migration of water and the growth of ice crystals during freezing could result in the deterioration of the frozen dough [3,4], which in turn induce the collapse, cracking and coarse texture of the product based on frozen dough preparation.

Nowadays, the use of food additives is one of common practices in food industry. Various food additives (hydrocolloids, enzymes emulsifiers etc.) are used to enhance dough handling properties and the quality of flour products [5,6]. Among these additives, hydrocolloids (water soluble polysaccharides and proteins with different chemical structures), are widely used in many fabricated food products in order to impart the required quality in terms of stability (gelling, thickening, emulsifying etc.), texture (in-product and in-mouth) and appearance [7,8]. They have been employed for diverse purposes in baking industry, to slow staling rate, improve texture properties, moisture retention, product acceptability and preservation [9-11].

Dough preparation is the first and critical step for making flour products, which involves complex physical and biochemical changes [12]. During the transformation from a water-wheat flour mixture into a dough, the three-dimensional gluten network is formed to build the backbone structure of dough by gluten proteins through numerous hydration, disulphide bonds and noncovalent interactions such as ionic bonds, hydrogen bonds and hydrophobic linkages [13,14]. Starch granules, fat and other components are trapped in this gluten network.

Dough performance plays a key role in final products quality. There has been much research on the improvement technique of dough quality in order to improve the scarce quality of wheat flour and the overall quality of final products, as well as to satisfy the need of different flour products [7,9,15]. Yousefi-Darani, Paquet-Durand and Hitzmann [16] studied the use of fuzzy logic for the control and improvement of the dough fermentation process and founded that this technique was efficient to evaluate the dough fermentation process with different proportions of yeast.

The quality of frozen dough depends on CO_2 production ability of yeast and CO_2 retention capacity of bread after fermentation. Decreasing yeast viability and destruction of dough network structure are regarded as two major factors that lead to the deterioration of dough quality while both are caused by ice crystals. The effects of ice crystals could be multiple: mechanical action of ice crystals may affect the structure and properties of the dough [3] and the larger the ice crystals, the greater the possible damage to the dough structure; the formation of intracellular ice crystals would pierce the cell membrane leading to yeast death [17]. Dough network structure, which can lead to the deterioration of final quality of the products if damage, is another essential factor for the quality of bread. The function of the dough network structure is similar to yeast, which affects the retention ability of CO_2, proofing time and loaf volume. The structure may also affect bread sensory properties such as firmness and chewiness and is tight after rapid thawing, as gluten matrix inlays with many small spherical starch granules. However, after several weeks of storage, starch granules have the tendency to separate from the gluten, indicating the damage of the network structure [18].

Several high-resolution analyzes can contribute to the study of the quality improvement of frozen masses, such as Scanning Electron Microscopy (SEM), X-ray Diffraction, Infrared Spectroscopy and others. Generally, the structure and the content of the damaged starch of the frozen dough can be observed by low temperature SEM.

Galvão., *et al*. (2018) studied the application of edible coatings in frozen bread dough and observed by scanning electron microscopy the coating protection against frost damage. Huen., *et al.* (2014) investigated the frozen wheat bread by confocal Raman spectroscopy.

In agricultural and food science and more specifically in cereal science, only little use has been made of this technique so far. Piot., *et al.* 2000, Piot., *et al.* 2001, Piot., *et al.* 2002 used confocal Raman microscopy for exploring the spatial distribution of starch, gluten, arabinoxylan and ferulic acid in wheat grains. Recently, Jääskeläinen., *et al.* (2013) performed similar investigations with higher (sub-μm) spatial resolution on barley and wheat grains.

In order to optimize the recipes and the production processes of frozen baked goods, it is essential to be able to monitor the phenomena occurring in the products in the frozen state. Differential scanning calorimetry (DSC) allows quantitative investigations of ice crystallization. Thermophysical properties of dough include effective thermal conductivity, apparent specific heat, ice melting enthalpy, freezable water fraction and ice fraction. These parameters can be used not only to simulate the heat transfer process but also to calculate the size of the ice crystals in frozen dough [19].

For monitoring the size and the distribution of the ice crystals as well as their mechanical interactions with the other components of the dough, imaging techniques are required. So far, scanning electron microscopy in the frozen state (cryo SEM) [3,20,21] and confocal laser scanning microscopy (CLSM) [22] have been used for that purpose. However, this method did not allow for generating precise images of the ice crystal structure. Due to these limitations, little is known about the structure of the ice crystals that are entrapped in the dough matrix, which yet represent the main part of the frozen water (Huen., *et al.* 2014).

Therefore, a continuous improvement study should be carried out on the frozen dough, especially with the aid of high-resolution analyzes that promote the elucidation of the mechanism of gluten-starch complex damage during the dough frozen storage, as well as the impact which various additives cause in this structure. Analyzes such as scanning electron microscopy and confocal microscopy can be directly correlated with the physical and sensory properties of the frozen dough, guaranteeing a constant advance in the improvement of bread quality.

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