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Effects of trehalose and dough additives incorporating enzymes on physical characteristics and sensory properties of frozen savory Danish dough

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ABSTRACT

For economic reasons dough freezing technique is nowadays commonly employed in bakery business. There are, however, several issues connected with this technology. To improve the quality of a ready product, baked from frozen dough, some attempts concerning manipulation of production process parameters as well as supplementation of dough formulas with additives have been made. The aim of this study was to analyze the effects of various additives, including ready to use bakery products, on the crumb structure and specific volume of baked savory Danish dough. The research results show that by using most of the selected additives, an improvement of the volume and crumb structure of the product baked from frozen dough can be achieved. The only exception is the supplementation of the dough with 2% of trehalose. The most similar properties to the control sample, baked without the use of freezing technique, were observed in 3 formulas. One was made with the use of a commercial product, the second using fungal α-amylase, whereas the third - a blend of fungal α-amylase, glucose oxidase, fungal amyloglucosidase and enzymatic complex of lipases and xylanases. Nevertheless, an impact of these additives on the flavor profile of the dough was noted.

1. Introduction

Frozen dough is now commonly used in the bakery business. Thanks to dough freezing, bakery products can be prepared quickly and on demand, thus minimizing the cost of unsold products (Giannou, Kessoglou, & Tzia, 2003). Moreover, such production technique ensures a better use of the machine park and enables the use of large batch production method which helps rationalize the production process and achieve the benefits of serial production (Yi & Kerr, 2009). Nevertheless, there are several issues connected with this technology i.e. loss of dough strength caused by formation of ice crystals, decreased retention capacity of CO_2, longer fermentation time, and reduced viability and activity of yeast. These may lead to the reduced volume and deterioration in texture of a baked product (Selomulyo & Zhou, 2007; Steffolani, Ribotta, Perez, Puppo, & Leon, 2012) as well as an extension of proofing time (Meziani et al., 2012a), compared to fresh dough products. Research shows that the longer the time of freezing, the more damage in gluten network as a result of the formation of large ice crystals However, the slow freezing rate has a positive effect on the survival of yeast (Yi & Kerr, 2009).

To improve the quality of a ready product, baked from frozen dough, some attempts concerning manipulation of production process parameters, such as: freezing and thawing rates, mixing time and storage duration, have been made (Rouillé, Le Bail, & Courcoux, 2000; Yi & Kerr, 2009). Some additives whose role is to improve dough properties, such as hydrocolloids or emulsifiers, were tested as well (Selomulyo & Zhou, 2007; Hejrani, Sheikholeslami, Mortazavi, & Davoodi, 2017). Adding extra amount of yeast or incorporating new strains of freeze-tolerant yeasts may be used as another way to improve the quality of a baked product (Yi & Kerr, 2009). Moreover, the addition of trehalose positively affects the survival of the yeast rate (Diniz-Mendes, Bernardes, de Araujo, Panek, & Paschoalin, 1999). Furthermore, Verachter and de Mot (1990) have found that an increased amount of trehalose has a positive effect on the fermentative activity of the yeast. An L-ascorbic acid, which acts as an oxidizing substance, has positive effects on the baked dough quality as well. It strengthens the gluten structure by disulfide bond formation, thus contributing to the improvement of the structure and volume of bread

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(Selomulyo & Zhou, 2007). In addition, L-ascorbic acid - by the action of endogenous enzymes or iron or copper - is oxidized to L-dehydroascorbic acid and hydrogen peroxide, significantly limiting the reduction of glutathione by glutathione dehydrogenase, which causes a weakening of the structure of the dough (Goesaert et al., 2005).

Particularly good results in the quality improvement of bakery products may also be achieved by the use of enzymes, which are moreover considered as safe for human health as they are deactivated during baking (Caballero, Gomez, & Rosell, 2007). Therefore, the enzymes are gradually gaining popularity as a component of baking additives, including those for frozen dough.

Fungal α-amylases are added to the dough to improve the fermentation properties of flour. They break down part of the starch to simpler compounds, such as dextrin, maltose or glucose. As a result, elasticity of bread crumb is improved and an increase in the volume of a bakery product is achieved (Almeida, Chang, & Joy Steel, 2013). Dextrin hinders the subsequent retro-gradation of amylopectin and the formation of crosslinks between gelatinized grains of starch and the gluten. This contributes to preserving the freshness of bread for a longer time and to slowing down the staling processes (Caballero et al., 2007; Goesaert et al., 2005; Kim, Maeda, & Morita, 2006).

Glucose oxidase catalyzes the oxidation of glucose, strengthens gluten and intensifies the production of CO_2, which results in improved baked dough volume. It counteracts the effects of dough freezing and improves crumb structure by contributing to the formation of larger amounts of bonds between proteins (Steffolani et al., 2012); thus, crumb becomes more elastic and cohesive (Caballero Gomez & Rosell, 2007).

Amyloglucosidase catalyze the hydrolysis of 1,4-glucosidic bonds of α-D-glucose residues sequentially starting with a non-reducing ends of the maltooligosaccharides and polysaccharides, thereby releasing β-D-glucose. Most forms of the enzyme can rapidly hydrolyze 1,6-α-D-glycoside bonds when the next in order is the 1,4-glycosidic bond. By such action fermentation process is accelerated. This, in turn, positively affects the bakery product volume and its stability during freezing (Gupta, Schmoll, Mazutti, M, ä, ki, & Tuohy, 2013).

Xylanase, thanks to the redistribution of water between pentosan phase and gluten, improves the resilience of gluten. As a result, the elasticity of the dough during baking is improved, thus the volume of the product increases. The use of xylanases leads to the degradation of large, water-insoluble particles of pentosans to small and soluble ones. This in turn contributes to inhibiting the staling process of bakery products (Steffolani et al., 2012).

With the lipases added mono- and diglycerides are released form fats. This improves the softness of bread, as well as its volume and helps to slow down the staling processes (Krog, Olesen, Toernaes, & Joensson, 1989).

Although, several studies have demonstrated that some additives, also those incorporating enzymes, have positive influence on the quality of bakery products manufactured form frozen dough, no study has showed their influence on the savory Danish dough. Savory Danish dough is a yeast-leavened dough that contains relatively high amounts of fat, which according to Carr, Rodas, Della Torre, and Tadini (2006), positively affects the quality of frozen bakery products. The dough becomes more soft and flexible, and thus has a higher ability to retain gas. Moreover, in savory Danish dough a reduced amount of sugar and higher amount of salt are used in comparison to traditional Danish dough recipe.

The aim of this study is to analyze the effects of the use of several additives, including ready to use bakery products, on the crumb structure and specific volume of a baked savory Danish dough. To achieve this aim, the following hypothesis was formulated: “Supplementation of savory Danish dough intended for freezing with selected additives helps obtain similar values of its properties to those characterizing the dough baked without freezing treatment”.

2. Material and methods

2.1. Flour

A commercial flour type 550 of the composition and parameters presented in Table 1 and in Fig. 1 was used in the research.

2.2. Additives used in the study

A detailed description of all additives used in the study is presented in Table 2. The amounts of additives supplemented to dough formulations are showed in Table 3.

2.3. Dough preparation

Danish dough was prepared with 2000 g of flour with an addition of 6% of sugar, 3% of sodium chloride, 44% of fat (Westfalia Zieh-block, Lindemann) and 7% of yeast (*Saccharomyces cerevisiae*) on the flour basis. The amount of yeast was increased in relation to the basic recipe due to predicted losses during freezing and storage of the dough (Giannou et al., 2003). As shown by Oda and Tonomura (1993), the presence of 3% salt positively influences leavening ability of yeast cells. The amount of the necessary addition of water was adopted as indicated by farinographic assays. All dough components were mixed using a Teknostamp SRL Planetariums LT60-VV-AA dough mixer. Total mixing time was 5 min (2 min at the speed of 140 rpm and 3 min at the speed of 160 rpm). Dormant yeast is less susceptible to low temperature (Huang, Kim, Li, & Rayas-Duarte, 2008). Accordingly, the dough mixing process should be carried out in such a way so as to ensure a minimum activity of the yeast. According Giannou et al. (2003), the temperature of the dough after mixing should be in the range between 19 and 22 °C. Too much activity of yeast before freezing of the dough negatively affects their cryoresistance (Havet, Mankai, & Le Bail, 2000). Considering the above and the production technology of fermented and half-fermented doughs, the temperature of the dough after mixing in these studies was set at a maximum level of 17 °C. The dough was rolled out with the use of a Rondo Doge Rondostar 4000 SFS 660 automatic sheeter. The thickness of the dough sample was fixed with the use of a Rondo Doge ZKWA 607A calibrator. Samples were cut out using a quadratic stainless steel forms.

2.4. Freezing and storage

The dough samples were frozen with the use of a blast freezerat the temperature of −30 °C (Meziani et al., 2012a,b) and stored for 7 days in a sealed container at −18 °C, as suggested by Huang et al. (2008), in order to minimize the yeast's activity.

2.5. Thawing and preparation of dough for analysis

The samples were thawed at the room temperature and proofed in a MIWE GS proofing cabinet (35 °C, 80% RH) until the manually verified optimum time. The proofing end was reached when the maximum dough volume was developed without losing its resistance to touch (Almeida & Chang, 2012).

After proofing, the dough samples were baked in the stainless steel and bottomless forms for 7 min at a temperature of 200 °C using electric oven MIWE aero.