FACTORS INFLUENCING QUALITY AND SHELF LIFE OF BAKING PRODUCTS

UTICAJNI FAKTORI NA KVALITET I ROK UPOTREBE PEKARSKIH PROIZVODA

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ABSTRACT

Bread is one of the oldest foods. Recipes and technology of baking have been modified to elongate its shelf-life and adapt to changing consumers’ preferences. Currently, highly acceptable sensory attributes of bread have been achieved using numerous preparations such enzymes, components improving its volume and antifungal compounds. Bakery products have a short shelf-life, resulting from adverse changes that begin just after baking and cause worsening of sensory features and texture of crumb. Elongation of the shelf-life has been achieved not only through recipe improvement but also packaging under modified atmosphere (MAP), application of intelligent packages or interrupted bread-making. All these approaches are designed to produce the highest quality bread retaining quality till the end of shelf-life. Maintenance of bread freshness has attracted attention of both bread manufacturers and consumers for years. This paper is a review of recent literature related to methods of bread shelf-life elongation.

Key words: bread, shelf-life, storage, additives.

INTRODUCTION

Bread-making technology has been changing for years. Traditional recipes were based on appropriate proportions of flour, leavening agent, water and salt. Currently bread has been manufactured using additional substances such as fats, milk, improved leavening agents, cereal grains, enzymes. These additives along with optimized parameters of technological processes were found to improve its sensory and nutritive characteristics (Fik, 2004). Cereal products including bread are recommended diet element representing the base of Food Guide Pyramid. Bread is rich in diverse nutrients such as: carbohydrates, proteins, fats, mineral substances, B-complex vitamins, vitamin E and other valuable diet components.

Bread quality is of importance because it is commonly consumed (Ambroziak, 1998). However, it is difficult to define this quality since it is affected by many factors such as the nutritive value, taste, freshness, shelf-life and attractiveness for consumers. Bakery products have a short shelf-life, resulting from adverse changes that begin just after baking and cause worsening of sensory features and texture of crumb. Ageing of bread is manifested by a partial decrease in humidity, growth of filamentous fungi and yeasts, and staling (Fik 2004). Bread staling has been investigated by numerous researchers both in Poland and abroad (Fik et al., 2000; Scanlon et al., 2000; Michalska-Pozoga and Raczkowska, 2011). Many of these studies focused on shelf-life extending through improvements in manufacturing technology or application of additives.

MATERIAL AND METHOD

Bakery products account for around 70% of all consumed cereal products. Their chemical composition, and nutritive and energy values depend on formulation, conditions of dough preparing and further steps of technological process, and additives (Grembecka, 2007). Bakery products are classified based on not only the type of flour, but also on conditions of baking-making or applied additives. Rye breads are produced from either leavened rye flour or using a pre-fermented leaven. Mixed rye breads are manufactured from mixtures of rye and wheat flours that are either subjected to leavening or mixed with the leaven, which can be supplemented with yeasts. Wheat bakery products are derived from wheat flour fermented with yeasts.

Bakery products are also classified based on the ash content in the flour. Dark bakery products are produced from flours containing more than 1.0% ash or from mixtures of flours with ash content above 1.06%. White bakery products are manufactured from flours with ash content below 1.0% or their mixtures (Ambroziak, 1998). Types of bread depend also on a country and tradition, which in turn depend on available cereals and sorts of flour.

Special, regional types of bakery products that are available on the market are either characterized by specific formulations or produced by unique technological processes (e.g. wheat bread rich in dietary fiber and vitamins, bread enriched with cereal bran, crisp bread, pumpernickel and durable bread, also named...
conserved bread). Also dietetic breads differ from commonly manufactured bakery.

Examples of dietetic bakery products are: high-protein bread, gluten-rich bread, gluten-free bread, low-sodium bread and rusks enriched with iron salts (Ceglińska et al., 2009). Skotnicka and Palich, 2007). One of most important technological parameters, influencing the ultimate quality of frozen products and their further shelf-life, is freezing rate. According to recommendations of the International Institute of Refrigeration, the temperature of bakery products should be quickly decreased to -7 °C (Polak et al., 2004; Yi and Kerr, 2009). Freezing is conducted by two methods: blast freezing with cold air and cryogenic.

**Packaging**

Objectives of packaging of bakery products include prevention of microbial contamination and maintenance of acceptable sensory properties. Besides, packaging should prevent a decrease in humidity. Bakery products with a relatively short shelf-life (1-2 days) are packaged in paper bags or perforated foils. Foil bags from PE-LD and PE-LLD are used to package sliced breads or specialty breads with a shelf-life of a few days as well as frozen bakery products. Products with an extended shelf-life should be packaged in polypropylene (PP) heat shrink and extensible foils. Because these foils are barriers to steam and other gases contained in air and are resistant at elevated temperature, they can be used to package hot and thermally preserved bakery products. Deluxe semi-confectionery products may be packaged in two-layer foils like polyamide/polyethylene foils or foils consisting of two types of polyethylene e.g. PE-HD/PE-LD (Michnie-wicz, 1998).

The shelf-life of bread and other bakery products may be also extended through packaging in modified atmosphere (MAP). This technology is based on replacement of air with inert gases. Bakery products are usually packaged in the atmosphere containing various proportions of carbon dioxide and nitrogen. Composition of recommended gas mixtures and resulting increase in bakery products’ shelf-life is shown in Table 1 (Guynot, 2003; Yi and Kerr, 2009; Hik et al., 2012).

Active packages used in food industry contain substances absorbing oxygen, which are usually entrapped inside small bags that are put inside the package. Depletion of oxygen prevents the growth of filamentous fungi thereby extending the shelf-life of foods like bread and other bakery products. One of these oxygen absorbers is a preparation named “Ageless”, which causes a 3-fold increase in a shelf-life of rolls kept in the atmosphere of inert gases (Tab. 2) (Yi and Kerr, 2009).

Table 1. Composition of gas mixtures used in MAP of selected bakery products and their shelf-life (Yi and Kerr, 2009)

<table>
<thead>
<tr>
<th>A sort of bakery products</th>
<th>Gas mixture composition</th>
<th>Temperature of storage [°C]</th>
<th>Shelf-life [days]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sliced rye bread</td>
<td>CO₂ [%]</td>
<td>70</td>
<td>21-28</td>
</tr>
<tr>
<td>Sliced toast bread</td>
<td>N₂ [%]</td>
<td>30</td>
<td>14-21</td>
</tr>
<tr>
<td>Baked rolls</td>
<td>80</td>
<td>5</td>
<td>21-28</td>
</tr>
<tr>
<td>Pizza</td>
<td>50</td>
<td>5</td>
<td>14-21</td>
</tr>
</tbody>
</table>

Table 2. Shelf-life of bread kept in active packages at temperature of 25 °C (Yi and Kerr, 2009)

<table>
<thead>
<tr>
<th>Atmosphere composition</th>
<th>Time until appearance of filamentous fungi [days]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atmospheric air</td>
<td>5-6</td>
</tr>
<tr>
<td>CO₂/N₂ (60:40)</td>
<td>16-18</td>
</tr>
<tr>
<td>N₂</td>
<td>9-11</td>
</tr>
<tr>
<td>Atmospheric air + “Ageless”</td>
<td>&gt;60</td>
</tr>
<tr>
<td>CO₂/N₂ (60:40) + “Ageless”</td>
<td>&gt;60</td>
</tr>
<tr>
<td>N₂ + “Ageless”</td>
<td>&gt;60</td>
</tr>
</tbody>
</table>

An alternative to bread packaging in the modified atmosphere (MAP), which insufficiently protects it from the growth of fungi (Nielsen and Rios, 2000) is application of active packages filled with volatile essential oils (EO) or oleoresins (OL) derived from spices and herbs. The antibacterial and fungistatic activities

**Chemical composition of bread**

Bakery products are rich in carbohydrates because of the high content of starch and simple saccharides. Levels of the latter carbohydrates depend not only on chemical composition of flour but also on amounts of sugars added during manufacturing process. Therefore, wheat bakery products usually contain more sugars than rye bread, which is not supplemented with other carbohydrates. Bakery products are an important source of dietary fiber apart from fruits and vegetables. Its content depends on a sort of flour and varies between 0.3 and 1.5 g/100 g fresh bread. Therefore, wholemeal breads contain elevated levels of dietary fiber. The latter is not digested in human gastrointestinal tract but positively affects peristalsis of intestines and enables expelling of harmful metabolites. Cellulose and hemicelluloses are main fractions of dietary fiber in wheat bakery products while in rye bread it embraces: pectin, gums and mucus substances (Ambroziak, 1998; Wojciechowicz and Gil, 2009).

Flour type and dietary fiber content influence also about concentration of other nutrients. Wholemeal wheat and rye breads contain 2-5-fold more salts of iron, magnesium, manganese, copper and zinc than white breads (Ambroziak, 1998).

Protein content in varies between 4.5 and 8.0 g/100 g fresh bread. Although wheat bakery products contain more proteins than rye breads, rye proteins are more valuable because of higher amounts of essential amino acid. Fat content in bakery products is low and varies between 0.7% and 2.5%. Therefore, bread can be kept for a relatively long time. Bakery products are rich in B-complex vitamins, in particular thiamine (vitamin B₁), niacin, riboflavin, and folic acid as well as vitamin E. Higher levels of these valuable ingredients are contained in wholemeal breads, particularly yeast-fermented wheat breads. Humidity content in rye breads reaches 50%, while in wheat breads it is up to 45% (Ambroziak, 1998).

Energy value of bakery products varies between 874 and 1924 KJ, it means 208-459 kcal/100 g fresh product with exception of pumpernickel and crisp breads, which are characterized by the higher energy value and content of nutrients (Ambroziak, 1998).

It is estimated that bakery products satisfy around 50% of nutritional needs of human and around 30% of energy needs.

**RESULTS AND DISCUSSION**

Preservation of foods including bread and other bakery products is based on methods that aim at extending their shelf-life through inhibition of microbial growth, retarding adverse chemical, biological or physical changes or protection from diverse contaminations and pests.

There are several methods extending the shelf-life of bakery products such as:


**Freezing**

Freezing is one of most widely used methods of bread preservation although it only slows down adverse physicochemical changes and does not eliminate them completely (Postolski, 2002; Barcenas and Rosell, 2006; Skotnicka and Palich, 2007). Freezing reduces losses of nutrients and worsening of sensory attributes during prolonged storage (Berliński and Bońca, 2007). This method is used mainly to prevent staling of bakery products through inhibition of starch retrogradation process (Ambroziak, 1999; Skotnicka and Palich, 2007).
of these substances were proven by numerous studies (Azouz and Bullerman, 1982; Shelef, 1983; Conner and Beuchat, 1984; Zaika, 1985). Essential oils are used in such concentrations which affect neither the taste nor the aroma of protected products.

According to Nielsen and Rios (2000), the highest fungistic activity was displayed by white mustard oil. Cinnamon, garlic and clove oils were only slightly less active. The shelf-life of rye bread was elongated when it was kept in an active package containing the white mustard oil containing - allyl isothiocyanate, which inhibits the growth of fungi.

### Thermal preservation

Thermal preservation considerably extends the shelf-life of bread and other bakery products. They are packaged in polypropylene foil and subjected to pasteurization. To destroy fungal spores the temperature of the core of bread crumb is increased to 85 °C and maintained at this level for 15 min. Temperature and duration of bread processing depend on its type, package and available equipment. Thermal processing may be conducted using a baking oven equipped with a system ensuring the maintenance of constant temperature or inside a switched-off baking oven, whose temperature is gradually decreasing (Michniewicz et al., 1992).

### Bioconservation

Bioconservation is an alternative method of bread preservation based on biological activity of lactic acid bacteria (LAB) that dominate the microflora of leaven. One of the attributes of this bacterium is the capability of inhibiting the growth of other microorganisms, which are responsible for the microbial spoilage of bread. Many species of lactic acid bacteria populating the leaven are members of genus Lactobacillus (Dal Bello et al., 2007; Ryan et al., 2008). Antagonistic activity of LAB strains is caused by synthesis of compounds strongly suppressing the growth of other microorganisms like organic acids, hydrogen peroxide and bacteriocins. Depletion of oxygen in the leaven is another factor terminating the growth of filamentous fungi and other aerobic microorganisms. Organic acids produced by LAB strains, which are protonated at low pH, cross the cytoplasm membrane of microbial cells and release protons at neutral pH inside these cells. The increased H+ uptake leads to acidifying the cells and disturbance of proton gradient across the cytoplasm membrane thereby decreasing the proton motive force, which is essential for ATP synthesis and metabolic activity of cells. Besides, the accumulated toxic anions interact with cell constituents, which is also harmful to microorganisms. Lactic acid shows the higher activity in inhibition of microbial growth that acetic acid with an exception of yeasts and filamentous fungi.

Hydrogen peroxide produced by LAB strains activates the lactoperoxidase system. Its products show antibacterial activity, in particular toward gram-negative bacteria of genera Escherichia, Salmonella and Pseudomonas. Bacteriocins, which are ribosomally synthesized peptides or proteins of LAB strains giving their producers a competitive advantage in the environment, cross cell walls of other bacteria and form ionic channels in the cytoplasm membrane, which triggers its depolarization leading to ceasing of proton motive force and cell’s death (Włodarczyk and Dłouhý, 1998; Dłouhý, 2004; Kowalski, 2005; Piestewicz, 2005).

### Chemical agents

As it was mentioned above, bakery products have a short shelf-life due to adverse changes that begin just after baking and cause worsening of sensory attributes and texture of crumb. Staling is the most important process causing a loss of bread quality. It is defined as an alteration of properties of bread and other bakery products, which is not caused by microorganisms (Michniewicz, 1998, Ambrozik 1999, Gil et al., 1999; Marzec et al., 2007). Staling is manifested by crumb hardening, changes in the color of crust, a decrease in solubility of starch and its recrystallization, and reduced water binding capacity of crumb (Hoseney and Miller, 1998; Van Dam and Hille, 1992). These processes occur at various rates and contribute to increasing hardness, dryness and fragility of crumb, decreased crispiness of crust and a loss of aroma, causing ageing of bread and gradual loss of usefulness as a food (Bhattacharya et al., 2002; Fik, 2004; Le Bail and Ribotta, 2007).

The improvement of the quality of bakery products and elongation of their shelf-life may be achieved using preparations of enzymes like amylases, lipases, proteases (Tenkamen et al., 1998), cellulases (Haros et al., 2002) or pentosanases. Other additives retarding the process of ageing are volume increasing agents, antifungal substances and other (lipids, preparations of malt, milk and dairy products etc.) (Jakubczak, 1988; Ambrozik, 1998; Drozdowski, 2007).

In recent years it has been observed an increasing interest in grains of cereals, which have not been used to bake bread, as additives to bakery products. Examples of such cereals are: oats, barley, buckwheat, sunflower, amaranthus and quinoa. Their application as bread additives result from valuable chemical composition since they are rich in dietary fiber, unsaturated fatty acids, mineral salts, B-complex vitamins and antioxidants. Additionally, they have either low or medium glycemic index (Dłouhý, 2010a ; Dłouhý 2010b).

### Enzymatic preparations

Increasing availability of microbial enzymatic preparations gave rise to their numerous applications in food processing including baking. Enzymatic preparations are added to dough to modify its components. For instance, amylases catalyze depolymerization of starch to dextrins and short oligosaccharides, which improves the porosity of crumb and increases its volume (Akers and Hoseney, 1994; Morgan et al., 1997; Vaseen et al., 2001; Caballero et al., 2007). Most suitable for this purpose are thermostable enzymes, which retain their activity at temperatures higher than the temperature of starch gelatinization and are thermally inactivated in late phases of baking (Fik, 2004). Commonly used in industry extracellular enzymes from Aspergillus niger and Bacillus megaterium display medium thermostability (Hebeda et al., 1991; Burrington, 1998). An example of amylolytic enzymes efficiently retarding bread staling are α-amylases (Laurikainen et al., 1998). Low molecular weight dextrans released from starch by these enzymes retard retrogradation of amylopectin and formation of cross-links between gluten and granules of gelatinized starch (Martin and Hoseney, 1991; Akers and Hoseney, 1994), α-Amylases act in a random manner and produce also some glucose stimulating the growth of yeasts and fermentation, which in turn give rise to formation of larger amounts of carbon dioxide and positively affect the texture of bakery products (Fik, 2004). The occurrence of starch depolymerization products contributes to the higher intensity of Maillard reactions during baking and thereby improves bread taste and coloration of the crust.

Treatment of dough with α-amylases reduces to some extent bread staling. However, it was found that when the extent of starch depolymerization catalyzed by thermostable α-amylase from Bacillus subtilis and strain was too high (the applied enzyme dose was too large) the quality of crumb was worsened due to the overproduction of soluble dextrans, which caused bread collapse immediately after taking out from oven. Besides, the crumb became rubber-like and viscous, which considerably hindered slicing (Qi Si and Droost-Lustenberge, 2002). Too high activity of fungal α-amylases used for dough treatment caused that the crust was too dark while the crumb was stretching. A good alternative seems to be dough treatment with malt α-amylase, which is thermally inactivated at the end of baking. This enzyme
converting gelatinized starch to long dextrins and does not cause its more advanced depolymerization. It also does not affect rheological properties of dough because its activity at temperature below 35 °C is low. This in turn minimizes the risk of disadvantageous changes of the dough, which are observed when the amylolytic activity is too high. Application of the latter α-amylase increased the shelf-life of bread by 4 days (Qi Si and Drost-Lustenberger, 2002; Goezaert et al., 2009).

Also other enzymes such as lipases, proteases, cellulases and pentosanases were successfully used for dough treatment resulting in extended shelf-life of bakery products (Olesen et al., 1994; Rouau et al., 1994; Tenkanen et al., 1998; Laurikainen et al., 1998; Haros et al., 2002; Katina et al., 2006; Caballero et al., 2007). Proteases are applied to loosen the structure of gluten, which in turn improves crumb structure (Fik, 2004).

Lipases catalyse hydrolysis of tri-, di- and monoglycerides contained in fats added to dough, which gives rise to the increase in softness of the crumb (Krog et al., 1989). This treatment improves loaf volume and structure of crumb, which becomes delicate, uniform and whiter. Products of fat hydrolysis released by lipases have emulsifying properties and therefore they can replace a part of emulsifiers, which are added to the dough (Spender et al., 2001; Christiansen et al., 2003; Moayeddollahie et al., 2010). This in turn may reduce costs of transportation and storage of emulsifiers, which are kept either in refrigerating conditions or frozen. The improvement in dough properties is caused by an increase in gluten strength, however, a too high enzyme dose gives rise to negative effects because the crumb becomes stiff and the volume yield is too low. (Krog et al., 1989, Qi Si and Drost-Lustenberger, 2002).

Other enzymes that are used for dough treatment are xylanases and pentosanases, enhancing the stability of dough, improving the structure of crumb, which becomes more delicate, and increasing loaf volume (Laurikainen et al., 1998; Qi Si and Drost-Lustenberger, 2002). Pentosanases catalyse the hydrolysis of pentosans, which gives rise to more uniform distribution of water in loaves and prevent the phenomenon of separation of crumb and crust during baking (Rouau et al., 1994). The action of xylanases increases the strength and elasticity of gluten. However, the complete disappearance of pentosans from the dough is disadvantageous because they are necessary for water binding. When the degree of pentosans hydrolysis is too high the crumb becomes viscous. The treatment of dough with both xylanases and fungal α-amyloses gives the synergistic effect (Qi Si and Drost-Lustenberger, 2002).

**Other additives**

Shelf-life of bakery products may be also extended by supplementing either flour or dough with natural or synthetic additives like emulsiyters and hydrocolloids (Hebeda et al., 1991; Korus and Achremowicz, 1994). They interact with cereal proteins during dough mixing thereby strengthening their structure, increasing elasticity of crumb and extending bread freshness, because they bind to starch during baking. Commonly used emulsifiers are mono- and diacylglycerols and other esters of fatty acids. One of natural emulsifiers is lecithin (Ambroziak, 1998). It was found that the crumb of bread supplemented with rapeseed or soybean lecithin was softer and more porous. Concomitantly, the loaf volume was increased and bread staling was slower (Haber et al., 1992; Lewczuk and Sobczyk, 1994). Addition of hydrocolloids was found to positively affect physical properties of gluten and retard hardening of crumb (Davidou et al., 1996).

Both the shelf-life and quality of bakery products were improved by addition of endogenous flour lipids (Kweon and Park, 1994; Collar et al., 1998), which decreased the rate of staling and hardening of crumb through formation of complexes with starch during baking (Soral-Smietana, 1989).

Also the enrichment of dough with proteins, wheat gluten, soybean flour or rich in proteins dairy products had a positive impact (Gallagher et al., 2002). Addition of defatted milk or whey improved the porosity and elasticity of bread crumb, crust coloration, nutritive value and taste of bread (Erdogdu-Arnowczy et al., 1996; Mannis and Arnowczy, 1999).

Bread quality was also improved through addition of non-starchy polymers, like pentosans (arabinoxylans), cellulose, lignin, betaglucans and pectin (Lawrukajtis-Klimkowska and Lawrukajtis, 1999). Arabinoxylans strongly influence the quality of bread because their content affects loaf volume, texture of crumb and staling rate (Biliaderis et al., 1995; Wang et al., 2002). Addition of arabinoxylans to the dough increases water binding capacity however, it may also contribute to faster retrogradation of starch. Consumption of bread rich in arabinoxylan fraction of dietary fiber reduces both amounts of glucose released to blood stream just after its intake and insulin secretion (Lu et al., 2000).

According to Michniewicz et al. (1992) the presence of pentosans hinders formation of intermolecular aggregates of amylose chains in the starch-gluten matrix, which in turn decreases the rate of starch retrogradation and bread staling. Also the enrichment of flour with 2% dry extract of apple pectin improves the quality and freshness of bakery products (Ballinger, 1992).

Hydroxypropylmethylcelullose (HPMC) is another additive applied to bakery. Its presence causes a rise in loaf volume, improves crumb structure and decreases the rate of staling of both conventionally baked products (Armero and Collar, 1996; Roseill et al., 2001; Guarda et al., 2004) and products obtained via interrupted baking (Barcenas et al., 2003; Barcenas et al., 2004; Barcenas and Rosell, 2006). Due to the hydrophilic character HPMC interacts with water (Sarkar and Walker, 1995; Schiraldi et al., 1996) and thereby prevents hardening of partially baked bread and slows down hardening of baked bread (Barcenas and Rosell, 2007).

Apart from the methods described above also other treatments are used to extend the shelf-life of bread and related products. They include the optimization of formulation, flour quality, dough-making process, fermentation conditions, proofing conditions, intensity of mixing, as well as earlier gelatinization of a part of flour before dough preparing and optimization of storage conditions (Ambroziak, 1999).

**Antifungal agents**

The growth of microorganisms like toxin-producing filamentous fungi and spor-forming bacteria is one of most important causes of the deterioration of quality of bread and other bakery products. It brings about substantial economic losses to manufacturers and consumers and poses a threat to health of the latter due to potential microbial infection (Diosoksz, 2004).

Microbial growth causes negative changes in the aroma, taste and texture of bakery products. It may also negatively affect dough fermentation. Principal sources of microbial contamination are flour and environment. Most harmful are Bacillus species like B. cereus, B. subtilis, and B. polymyxa, which begin to grow after 24 h of bread storage, and filamentous fungi, which are visible after 2 days of storage. The latter grow optimally at the relative air humidity above 70 % and at temperatures ranging between 20 and 30 °C. Most often encountered fungal contaminants are species of genera: Aspergillus, Rhizopus, Fusarium and Penicillium.

Noteworthy, almost one third of these fungal species produce toxic secondary metabolites such as mycotoxins, which have a harmful impact on human immunological system, are potential carcinogens and cause the irreversible damage of kidneys. Their examples are: aflatoxins, ochratoxin A, triothithenes and zearelenones. Mycotoxins are stable at elevated temperature and therefore they are not degraded during baking, which destroys only vegetative forms of microorganisms. Because of these rea-
sons, certain substances extending the shelf-life and inhibiting microbial growth, like chemical preservatives have to be added to baked products. Also leavening prevents the development of pathogenic microflora because the aforementioned lactic acid bacteria inhibit the growth of some other bacteria, yeast and filamentous fungi (Dworszcz, 2004).

Chemical preservatives used in bread-making are commonly used in food preservation. They cause destruction of cytoplasmic membranes and inhibition of enzymes. Commonly used agents are propionic acid and calcium propionate. Propionic acid is a liquid with unpleasant smell, which inhibits the growth of filamentous fungi and is used in doses below 2 g/kg product (Chuchłowa, 1996). It retards the growth of filamentous fungi and germination of Bacillus spores, but does not impair yeast development (Ponte and Tsen, 1987). Also calcium propionate is used as a preservative but it imparts a weak bitter taste to bread, decreases the activity of yeasts used for leavening and causes faster loss of water by bakery.

According to European Parliament and Council Directive No. 95/2/EC, the level of propionic acid in bread cannot be higher than 3000 ppm (EU, 1995). However, recent studies showed that this concentration is not sufficiently high to prevent the growth of bread spoiling microflora (Lavermicocca et al., 2000; Ryan et al., 2008). Besides, low levels of chemical preservatives used in bread-making may stimulate the growth of fungi (Marin et al. 1999) and biosynthesis of mycotoxins (Yousef and Marth, 1981; Gareis et al., 1984; Bullerman, 1985).

Another chemical agent, applicable to bread preservation, is sorbic acid. It is less harmful to consumers’ health, does not affect the taste and is more efficient in lower doses compared to propionic acid (Chuchłowa, 1996).

**Technological process**

The quality and shelf-life of bread and related products are also affected by duration and temperature of baking. Differences in texture of the crumb derived from the same dough but baked in different conditions are ascribed to differences in the rates of temperature increase inside the bread core, which depend on heating method and size of baked product.

The structure of crumb is known to depend on the course of gelatinization of starch granules (Dreese et al., 1988). The dynamics of temperature growth inside the bread core influences the kinetics and degree of swelling of starch granules, and the extent of changes in the crystallinity of amylpectin and amylose that in turn influence the crumb structure and its alteration during the storage. Bread baked at a high heating rate contains less humidity than bread baked at a lower heating rate. Humidity of bread depends also on heating method, so on the type of baking oven (using hot air or microwaves) (Patel et al., 2005). The ultimate humidity level on completion of baking process strongly affects the dynamics of bread ageing (Walker and Li, 1993; Yin and Walker, 1995; Patel et al., 2005).

The relatively low rate of heating causes that the enthalpy of amylpectin crystallization is lower, the crumb contains less soluble amylpectin and bread staling is slower (Patel et al., 2005). Thus heating rate and method affect attributes of bakery products, together with its staling rate. Differences in bread firmness and the extent of its changes during the storage are caused by differences in the degrees of hydration and swelling of starch granules, as well as distribution and aggregation of amylose molecules, which are determined by the rate of heating during baking.

**CONCLUSION**

Extension of shelf-life of bakery products has been achieved by various methods like: freezing, packaging, thermal processing, bioconservation, chemical agents addition and others.

All these methods are more efficient when appropriate additives are used in manufacturing of bakery products. Some of them like enzymes, leaven, fats, and antifungal agents contribute to elongated shelf-life of these products. They also positively affect technological operations during bread-making and shorten duration of the whole process (e.g. enzymes, leaven, yeast, agents increasing porosity and quality, dairy products, potato products), while some other impart the suitable taste (salt, sugar etc.).

Apart from the improvement of technological characteristics, appropriate additives increase the nutritive value of bakery products. They cause a rise in the content of proteins and exogenous amino acids, unsaturated fatty acids, mineral salts, dietary fiber, and vitamins. This in turn enhances health-promoting effects and renders such bakery products attractive diet components. Particularly attractive additives are: dietary fiber, levens, and dairy products as well as barley, oats, spelt, and amaranthus – as representatives of cereal grains, which were not used in traditional bread manufacturing.

Application of synthetic additives is caused by the necessity of reducing the time of bread-making process, changing preferences of consumers and the need of inhibition of the growth of microorganisms, mainly filamentous fungi. Their growth excludes bakery products as a food and causes economic losses.

Therby, application of suitable natural and synthetic additives in manufacturing of bakery products may improve their beneficial impact on human health and sensory quality, and extend the shelf-life.

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