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IMPACT OF POTASSIUM IODATE ON THE QUALITY OF WHEAT-SPELT BAKED GOODS*

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Background. Human nutrition is oftentimes deficient to important nutrients such as iodine not only in the developing countries but also in the developed countries. Bakery products are consumed every day by many people and offer spread potential for enrichment of final products by various type of nutrients. The study is focused on the monitoring effect of potassium iodate as bakery improver to the quality of wheat-spelt baked goods through methods of rheological, baking test and sensory analysis. The influence of potassium iodate on baked goods staling was also studied.
Material and methods. Rheological properties of wheat-spelt dough enriched with potassium iodate were characterised by farinographic measurements. The final product analysis included determination of loaf quality (volume, specific volume, cambering) and sensory attributes. Crumb hardness was evaluated by the manually operated penetrometer AP 4.
Results. Potassium iodate influenced the final quality of wheat-spelt baked goods in different ways. Addition increasing doses of potassium iodate reduced dough development time and prolonged dough stability. Results of baking test and sensory analysis showed that products containing dose 1 and 2 mg of potassium iodate had higher volume and cambering in comparison to control sample. Higher dose of this additive negatively affected sensory parameters of final products.
Conclusion. It was found that enrichment of baked goods with potassium iodate not only helps increase to daily intake of iodine and but also positively affects rheological and sensory properties of final products.

Key words: dough, rheological properties, potassium iodate

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INTRODUCTION

Iodine has been recognised by the World Health Organization to be one of the most critical nutrients world-wide with nearly two billion people, or 35.2% of the global population, having inadequate iodine nutrition [Winger et al. 2008]. Lack of iodine can cause irreversible health problems including mental retardation, goiter, cretinism and childhood mortality. Therefore, iodine deficiency disorder is not only a nutrition and public health concern; but it is also considered to be a major problem to human and economic development [Chavasit et al. 2002]. Several ways are recommended how to avoid iodine deficiency in food of many countries' population [Špačková et al. 2001]. Iodine can be added to salt in the form of potassium iodide or potassium iodate. Because potassium iodate has higher stability than potassium iodide in the presence of salt impurities, humidity, and porous packing, it is the recommended form in tropical countries and those with low grade salt [Zimmermann 2009]. In addition to the common use of salt fortified with potassium iodide, potassium iodate can also be used in bakery products [Špačková et al. 2001].

At the beginning of the 20th century a number of oxidizing agents added to flour, in small quantities, seemed to have a major effect on baking performance. These products improved the fermentation, elasticity, and stability of dough. Dough became stronger, oven rise was larger, and crumb grain became fine [De Leyn 2006]. Oxidizing agents can be also very effective in improving the handling characteristics of dough and the specific volume and (indirectly) the texture of the finished products [Matz 1991]. These substances have an effect on the gluten proteins of flour. They change the gluten characteristics from weak into stronger gluten. They promote the formation of disulphide bonds through the oxidation of thiol groups. By creating additional disulphide bonds in the gluten, the oxidizing agents strengthen the gluten network [De Leyn 2006]. A common oxidizier is potassium bromate, but potassium iodate, calcium peroxide, and ascorbic acid are also used to some extent [Matz 1991].

Potassium iodate is a fast-acting oxidant [De Leyn 2006] that is completely consumed during mixing, consequently the improving effect of iodate is limited to the dough mixing process [Wieser 2003]. Iodate acting on the free sulphydryl groups of cysteine in the wheat protein chain [Špačková et al. 2001]. By oxidizing sulphydryl groups, iodate is reduced already during mixing of the dough and it reaches the consumer as iodide [Bürgi et al. 2001] and due to cystine production this way a 3-dimensional network of protein chains is formed [Špačková et al. 2001]. It was suggested that for iodate the optimum level of addition is in the range of 10-20 mg per kg [Wieser 2003].

MATERIAL AND METHODS

Dough rheological characteristics. Effect of different dose addition of potassium iodate on dough rheology during mixing was determined by farinograph (Brabender, Düsseldorf, Germany). The farinograph was equipped with a bowl for 300 g of the flour. The following parameters were determined: water absorption capacity, dough development time, dough stability, mixing tolerance index and degree of softening after mixing dough for 12 min after reaching the optimum.

Baking procedure. Laboratory baking was made using a straight dough method. A process was performed using the following ingredients: composite flour (commercially available fine wheat flour and wholemeal spelt flour were mixed in ratio 85:15, w/w) 300 g, salt 5.63 g (enriched with 27 mg of potassium iodate per kg of salt), sugar 3.22 g, yeast 12.06 g, sunflower oil 7.50 g, potassium iodate (0, 1, 2, 3, 5, 10 mg per 300 g of composite flour) and water (according to farinograph data to reach a consistency of 400 BU – Brabender Units). Chemical composition of applied flours is presented in Table 1. The raw materials were mixed for 6 min in farinographic mixing bowl. After 20 min fermentation, the dough was divided into 100 g loaves, formed on dough former, proofed 45 min and baked in an electric oven (Mora, type 524, Hlubočky – Mariánské Údolí, Czech Republic) during 10 min at 230°C.

Table 1. Proximate chemical composition of applied flours

Constituent*	Fine wheat flour	Wholemeal spelt flour
Moisture	11.4 ±0.20	10.6 ±0.10
Ash	0.7 ±0.01	1.74 ±0.10
Protein (N × 5.7)	12.1 ±0.20	16.3 ±0.30
Starch	86.9 ±1.30	68 ±0.80
Wet gluten	34.5 ±0.40	43.8 ±0.50

*Expressed on a dry matter basis. Values are averages of three repetitions.

The loaf quality and sensory attributes were evaluated after cooling for 2 h at room temperature. Sensory evaluation was accomplished by the 4-point hedonic scale determination by 11 assessors. The assessors evaluated: shape of product, crust colour and thickness/hardness, crust/crumb odour and taste, crumb: elasticity, porosity colour, resistance to the bite and adhesiveness to palate on longer chewing. Evaluation of loaf quality included: the loaf volume (cm^3), specific loaf volume (cm^3 per 100 g of loaf), cambering (loaf height/width ratio). Millet seeds were used to measure loaf volume as a difference of volume of empty bowl and the bowl with the baked loaf.

Crumb hardness. The manually operated penetromether AP 4 made in the former GDR was used. Half-spherical penetrating element of diameter 25 mm was applied. Crumb hardness was measured on freshly baked loaves (2 h after baking) and on loaves that were stored for 24, 48 and 72 h at ambient temperature using a manually operating penetrometer AP 4/1 (Feinmess, Germany) when 1 penetrating unit (PU) represented 0.1 mm.

The 30 mm thick slices were cut from the central part of individual loaves and were used for penetration analysis. Crust hardness was measured in the centre of slices.

Statistical analysis. Data were evaluated by analysis of variance with t tests at a confidence interval of 95% using the Origin Version 5 (Northamton USA). All experimental trials were performed in triplicate and expressed as means of three replications.

RESULTS AND DISCUSSION

Oxidation plays a central role in the breadmaking process. Addition of oxidants at optimum levels to flour or dough normally results in improved dough handling and bread quality. During the mixing, oxidizing agents convert SH groups of the gluten protein to SS linkages between adjacent molecules, building up the gluten matrix and providing a stronger dough [Giannou et al. 2003]. In this study, effect different doses of oxidation agent – potassium iodate on the wheat-spelt dough rheological properties a final quality of baked goods was determined.

Good baking quality is dependent on several rheological and physico-chemical properties of plant material and dough [Angioloni et al. 2009]. Dough rheological properties depend on the structure and also on the arrangement of constituents and forces between them [Angioloni and Rosa 2007]. Several methods are available to measure the rheological characteristics of wheat flour dough [Indrani and Rao 2007]. During this survey, the farinograph was applied for evaluation of selected rheological parameters of blend dough (results are presented in the Table 2). The water absorption capacity of flour defines its quality and its aptitude to form viscoelastic dough [Berton et al. 2002]. Determination of optimal water needed to obtain a certain dough consistency is essential to give dough with optimal handling characteristics [Ram et al. 2005]. Water absorption capacity of wheat-spelt blend flour was not markedly affect with increasing dose of potassium iodate (varied between 57.3 and 59.2%). Dough development time is the time from the first addition of water to the time the dough reaches the point of greatest torque. During this phase of mixing, the water hydrates the flour components and the dough is developed [Dervas et al. 1999, Doxastakis et al. 2002]. The dough development time decreased with increasing dose of potassium iodate (from 6 to 2.25 min). Dose of 1 a 2 mg of potassium iodate reduced dough development time about 50%. The dough stability was clearly affected potassium iodate, obtaining a increase of the stability at the highest potassium iodate concentration tested. A longer dough stability period indicates a stronger tolerance to mixing and greater flexibility in blending operations [Stiegert and Blanc 1997, Kohajdová and Karovičová 2007].

Table 2. The effect of different potassium iodate on farinograph characteristics

Samples	S	Addition of potassium iodate, mg per 300 g of dough				
	0	1	2	3	5	10
Water absorption, %	59 ±1.00	59.20 ±0.80	58.60 ±0.80	57.30 ±1.10	57.80 ±0.85	59 ±0.80
Dough development time, min	6 ±0.20	3 ±0.20*	3 ±0.20*	2.50 ±0.10*	2.50 ±0.05*	2.25 ±0.05*
Degree of softening, BU	80 ±2.00	70 ±1.50	70 ±1.50	80 ±2.10	80 ±1.90	115 ±2.50*
Dough stability, min	5.50 ±0.10	5 ±0.05	6.50 ±1.10	6 ±0.85	6 ±1.20	7.50 ±0.20
Mixing tolerance index, BU	50 ±2.50	60 ±2.20	45 ±1.00	55 ±1.50	60 ±1.50	40 ±1.50
Elasticity, BU	70 ±2.10	60 ±1.50	60 ±1.50	60 ±1.70	60 ±1.70	60 ±2.00

*Means are significantly different from control sample at $\alpha = 0.05$.

Results of baking test were expressed as the loaf volume, loaf specific volume and cambering (Table 3). It was concluded that the highest positive effect on the volume of products was recorded by addition of 1 and 2 mg of potassium iodate (increase approx. 21 or 25% in comparison to baked goods without potassium iodate). Application of higher doses of potassium iodate concluded in decreased volume of baked goods (statistically significant differences at $\alpha = 0.05$). These findings are in agreement with Joye et al. [2009] which stated that iodate supplementation of flour often results in over-oxidised dough and decreased loaf quality [Joye et al. 2009].

Table 3. Results of baking experiments

Sample	S	Addition of potassium iodate, mg per 300 g of dough				
	0	1	2	3	5	10
Amount of added water, cm^3	186 ±3.50	177.30 ±2.70	175.80 ±2.15	174.90 ±1.85	174.30 ±1.50	173.70 ±2.05
Before baking weight, g	100 ±2.50	100 ±2.00	100 ±1.50	100 ±1.50	100 ±1.70	100 ±1.80
After baking weight, g	90.20 ±2.00	88.20 ±1.80	89.20 ±2.40	90.20 ±2.20	89.70 ±1.90	89.70 ±1.90
Loaf volume, cm^3	240 ±3.10	290 ±3.20*	300 ±3.25*	255 ±2.50	253 ±2.10	250 ±2.15
Specific volume, cm^3 per 100 g	266.10 ±2.50	328.80 ±1.80*	336.30 ±2.00*	282.70 ±1.95	282.10 ±1.90	278.70 ±2.00
Cambering	0.52 ±0.02	0.60 ±0.02	0.61 ±0.03	0.60 ±0.02	0.59 ±0.01	0.59 ±0.02
Baking loss, %	9.8 ±0.20	11.8 ±0.30	10.8 ±0.20	9.8 ±0.25	10.3 ±0.20	10.3 ±0.25

*Means are significantly different from control sample at $\alpha = 0.05$.

The sensory profiles of potassium iodate enriched baked goods compared to the control sample are shown in Figure 1. The baked goods with 2 mg dose of KIO_3 were the most acceptable from the sensory point of view (Fig. 1). Statistically significant differences (at level $\alpha = 0.05$) were found for baked goods containing 5 and 10 mg dose of additive. These products had markedly darker colour, lower cambering values, slightly perceptive bitter taste and were characterised with decreasing crumb elasticity in comparison with control samples (without additive).

Staling of baked products is generally defined as an increase in crumb firmness and a parallel loss in product freshness [Haros et al. 2002]. The mechanism responsible for bread staling has been continuously reviewed but several aspects remain unclear [Rojas et al. 2001]. Understanding the different aspects of staling and the factors that affect them can help bakers make better decisions about their formulas, ingredients, processes and packaging [Angioloni et al. 2009]. Bread staling study realised on the final products showed that addition of potassium iodate prolongated shelf life of baked goods (Fig. 2). It was also found that this additive retard baked goods staling mainly in first 24 h of storage.

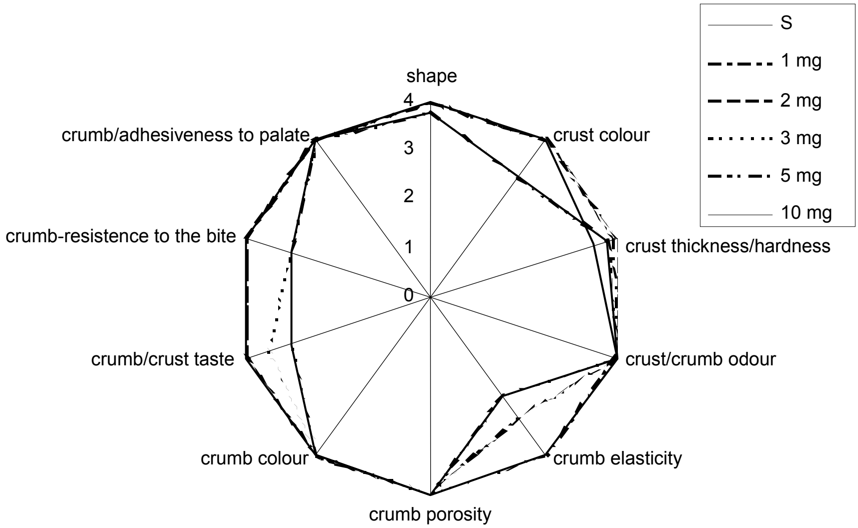

Fig. 1. Sensory parameters of baked goods with different doses of potassium iodate

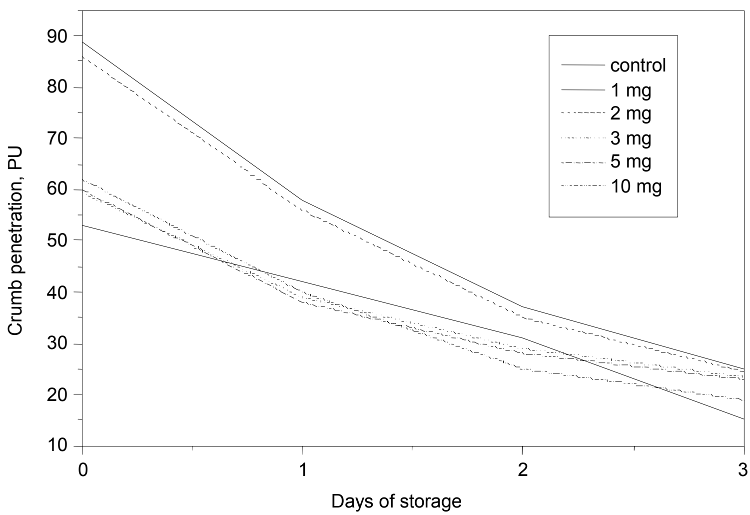

Fig. 2. Influence of different doses of potassium iodate on staling of baked goods

CONCLUSION

In this study, influence of potassium iodate on the rheological properties of wheat-spelt dough and overall quality of final products was studied. It was stated that dose 2 mg of potassium iodate per 300 g of flour positively affected handling properties of dough systems and qualitative parameters of baked goods. Further study will be necessary for determination of potassium iodate losses in this type of bakery products, but it is the supposition for good retention of this compound, because it is well know that potassium iodate is a heat-stable source of iodine, which remains stable through most of the severe cooking conditions (up to 560°C) [Chavasit et al. 2002, Winger et al. 2008].

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WPŁYW DODATKU JODANU POTASU NA JAKOŚĆ PIECZYWA ORKISZOWEGO

Wprowadzenie. Żywność często jest niewystarczającym źródłem ważnych składników odżywczych takich, jak jod. Dotyczy to krajów nie tylko rozwijających się, ale również rozwiniętych. Wyroby piekarnicze są wykorzystywane codziennie przez wielu ludzi. Ich rozpowszechnienie daje możliwość wzbogacenia produktów końcowych w różnego rodzaju składniki pokarmowe. Celem badań było monitorowanie wpływu obecności jodanu potasu użytego jako polepszacza na jakość pieczywa orkiszowego przez wykonanie badań reologicznych, testu wypieku i badań sensorycznych. Sprawdzano również wpływ dodatku jodanu potasu na czerstwienie tych produktów.
Materiał i metody. Właściwości reologiczne ciasta orkiszowego wzbogaconego w jodan potasu badano za pomocą farinografu. Ocena końcowego produktu obejmowała badanie jakości bochenka (objętość, objętość specyficzna, wygięcie) oraz wyróżników sensorycznych. Twardość miękiszu oceniano za pomocą penetrometru AP 4.
Wyniki. Jodan potasu wpływał wielokierunkowo na końcową jakość pieczywa orkiszowego. Dodatek wzrastających dawek jodanu potasu wpływał na skrócenie czasu fermentacji ciasta oraz przedłużenie stabilności ciasta. Na podstawie wyników badań i analizy sensorycznej produktów pieczonych wykazano, że produkty zawierające 1 i 2 mg jodanu potasu miały większą objętość i wygięcie w porównaniu z próbą kontrolną. Większe dawki tego dodatku wpływały negatywnie na cechy sensoryczne produktu finalnego.
Wnioski. Stwierdzono, że wzbogacenie pieczywa jodanem potasu nie tylko pomaga w zwiększaniu dziennej podaży jodu, ale także poprawia właściwości reologiczne i sensoryczne produktu finalnego.

Słowa kluczowe: ciasto, właściwości reologiczne, jodan potasu

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