Simultaneous Enrichment of Wheat Flour with Iodine and Improvement of Rheological Properties of Wheat Dough

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Abstract

ŠPAČKOVÁ Z., PŘÍHODA J., ROVNANÍKOVÁ S. (2001): **Simultaneous enrichment of wheat flour with iodine and improvement of rheological properties of wheat dough**. Czech J. Food Sci., **19**: 219–224.

Several ways are recommended how to avoid iodine deficiency in food of many countries' population. In addition to the common use of salt fortified with KI, KJO_3 can also be used in bakery products. It is also a strong oxidizer improving rheological properties of dough. In this paper the effect of KJO_3 on rheological properties of wheat dough and baked products was studied using farinograph and extensograph data and the baking test. The effect of KJO_3 was tested in combination with a commercial complex improver. Loaf volume was increased by the addition of 2 or 3 ppm of iodate to flour. The dose of iodine improving bread volume showed satisfactory correspondence to 50% of recommended daily intake that is allowed for bakery products by the Czech law.

Keywords: wheat dough; rheological properties; dough oxidizing; iodine fortification

One of the current nutritional problems is how to avoid iodine deficiency in the daily food for a substantial part of world population. Considerable iodine deficiency is also reported in some of the East and Central European countries and in many Asian countries (KUNACHOWICZ *et al.* 2000; MURTU *et al.* 1999; ZAMRAZIL 1998; NORDMARK 1999; CUTHBERTSON *et al.* 2000).

The adult body contains in average 10–15 mg iodine. Almost 80% of this is concentrated in the thyroid gland, the rest is located in blood and muscles.

World Health Organization (WHO) recommends 150–300 μg iodine as optimum average daily intake. A dose of 100–150 μg is considered a necessary minimum, and doses lower than 100 μg are insufficient. The doses exceeding the daily optimum are not risky, except for people suffering of struma. In some countries the daily consumption is approximately 400 μg (Northern Europe) or even 500–1000 μg (North America) (FIEDLEROVÁ & KOPECKÝ 1996) .

Based on the Czech law No. 110 (Zákon o potravinách 1997), the daily reference dose of potassium iodate is 252.9 μg. Out of this amount, 50% is allowed to be added to each 100 g of bread and standard bakery products.

There are several ways to eliminate iodine deficiency:
– to increase consumption of food naturally rich in iodine (e.g. sea food),
– to enrich food with iodine compounds,
– to supply special medicaments containing iodine.

Potassium iodide or casually potassium iodate have been usually used for food enrichment. Iodide ions, if inorganic, are directly absorbed by the walls of the digestive tract, while iodate has to be first reduced to iodide.

Iodide is usually added to foods using sodium chloride enriched with KI. Thus the balance of iodine added is dependent on the amount of NaCl used in the respective food formula. However, there is a common tendency to keep sodium in food low. The use of iodate is independent of the content of NaCl.

In this project potassium iodate was used for two reasons:
1. to examine which doses can improve rheological properties of dough,
2. to compare these effective doses with the dose recommended for food enrichment.

The use of oxidizers in wheat flour has been well known for a long time. Iodate is a strong oxidizing agent acting on the free -SH groups of cysteine in the wheat protein chain. Due to cystine produced this way a 3-dimensional network of protein chains is formed. Iodate is the fastest of all oxidizers used to strengthen the structure of wheat dough. Consequently the dose of iodate has to be observed very carefully to avoid the impairment of dough elasticity (BLOKSMA 1972; KAMMAN 1984; HOSENEY 1994).

MATERIALS AND METHODS

Standard wheat flour T 530 of local origin (ash content 0.60% in D.M., Falling number 258 s, Gluten index 89%) was used for all the tests performed. KIO_3 of analytical grade was dissolved in distilled water so that l ml of solution contained the quantity corresponding to 1, 2, 3, 6, 9, or 21 ppm KIO_3 in flour. A farinographic bowl for 300 g of flour was used for mixing. In all cases 1 ml of iodate solution was added to the bowl prior to adding water. Consequently, the actual iodate concentration in water added was 3-fold of the respective dose per 100 g flour.

Standard methods (ISO 5530-1: Wheat flour–Physical characteristics of doughs, Part 1: Determination of water absorption and rheological properties using a farinograph and ISO 5530-2: Wheat flour–Physical characteristics of doughs, Part 2: Determination of rheological properties using extensograph) were used for farinographic and extensographic tests. In principle dough was mixed in the farinograph mixing bowl to the optimum dough consistency and the amount of water (water absorption) was determined. Other characteristics used were the time in minutes needed for reaching optimum consistency (dough development time) and the "degree of dough softening" after mixing dough for 12 min after reaching the optimum (i.e. the maximum on the curve of consistency).

In the extensographic testing a standard stripe of dough prepared in a farinographic mixer was extended by constant speed until it ruptured. Resistance to the extension and the extension were recorded in time. The area under the curve plotted was expressed as "extensographic energy". All farinographic and extensographic tests were repeated three times and the values presented are means of three replications.

In test baking standard dough (300 g flour, 12 g fresh yeast, 5.1 g salt, 4.5 g sugar, water to farinographic consistency 600 farinographic units) was mixed in farinographic mixing bowl. After 45 min of fermentation dough was divided into 70 g loaves that were baked after 50 min proofing at 240°C (starting temperature) for 14 min. For every formula five loaves were measured. All values presented are means of these five replications. Specific volume 2 hrs after baking was terminated. Mustard seeds were used to measure loaf volume as a difference of volume of empty bowl and the bowl with the baked loaf.

Crumb toughness was evaluated immediately after the volume measurement. The manually operated penetrometer AP 4 made in the former GDR was used. A cylinder 3 cm heigh and 3 cm in diameter was excised from the crumb of baked loaf. Half-spherical penetrating element of diameter 25 mm was used.

In some tests commercial improver Naturback 2® (Lactoprot-Zeelandia Ltd., České Budějovice, CR) was applied. This improver is based on malt flour, emulsifier, hydrocolloid, ascorbic acid, and amylase mixture. 2% of improver was added in combination with the above mentioned doses of KIO_3.

Retention of iodine after baking process was evaluated using the spectrophotometric method of iodine determination (FIEDLEROVA 1998).

RESULTS AND DISCUSSION

The effect of pure iodate addition on farinographic characteristics is shown in Figs. 1 and 2.

Although the measurement of fresh dough often yields results that vary because of possible inhomogenities of dough deformations in the mixing bowl, general tendencies in the changes of both of the characteristics are obvious. Dough is strengthened with the increasing iodate doses. The effect on degree of softening starts from the lowest amounts tested but is accelerated by increasing con-

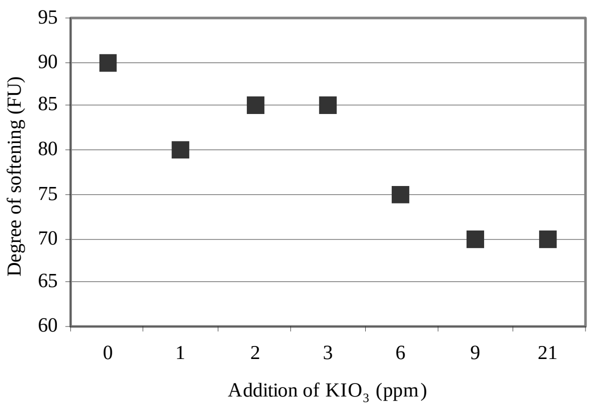

Fig. 1. Effect of iodate addition on farinographic degree of softening

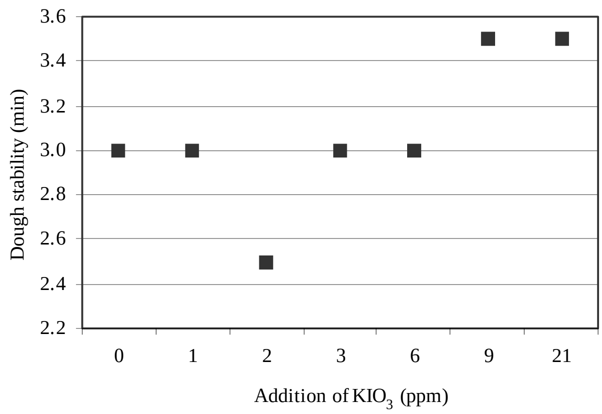

Fig. 2. Effect of iodate additon on farinographic stability

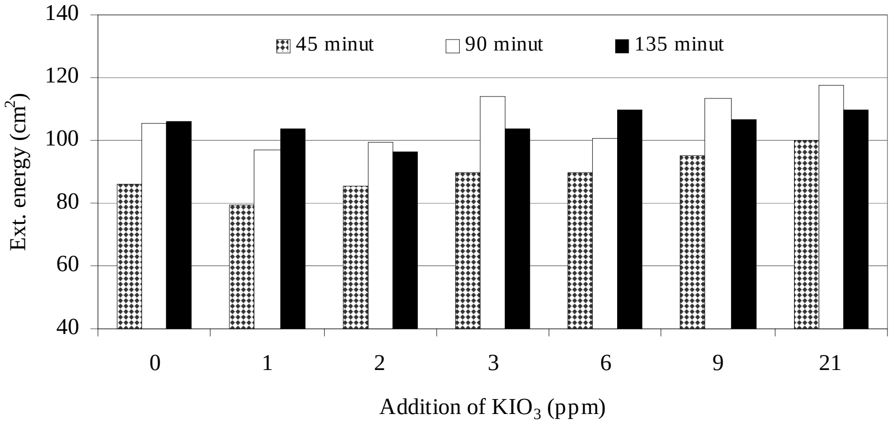

Fig. 3. Effect of iodate additon on extensographic energy after different resting periods of dough (45, 90, and 135 min)

centrations above 3 ppm. The effect on stability can be observed at the doses higher than 6 ppm. The effects on other farinographic values were not so clear.

The effects on extensographic parameters can be described as significant increase of resistance in doses higher than 6 ppm, and slight decrease of extensibility in doses exceeding 3 ppm. The effect on extensographic energy is shown in Fig. 3. It can be seen that energy decreased after the application of the lowest iodate doses, and then it increased with increasing doses. A minimum of energy was moving depending on the resting period of dough. After 45 min of resting time the dose of 2 ppm showed the same energy as without iodate, higher doses increased energy. After 90 min the same energy as without iodate was reached with the doses higher than 2 ppm, and after 135 min 3 ppm iodate was necessary to reach the same energy.

The results of test baking are expressed as the loaf specific volume and the depth of penetration in Figs. 4 and 5. It is obvious that different conclusions can be drawn concerning the effect of potassium iodate alone added to wheat dough, if we only use the results of rheological instrumental measurements, or if we compare them with the baking test results. Results of baking showed that even the lowest doses of iodate used improved both specific volume and penetration. It seems that doses higher than 3 ppm did not further improve baking test results.

The use of iodate in combination with the commercial improver Naturback 2® showed surprisingly two seemingly contradicting effects. When 2% of improver was added to flour (as recommended by the producer) in combination with any of the already mentioned doses of KIO_3, extensographic energy almost always decreased irrespective of dough resting time. On the other hand these complex mixtures caused a considerable increase of loaf specific volume and crumb penetration, as is shown in Table 1.

The best results of volume increase in laboratory baking tests were obtained with the addition of 2 ppm iodate (increase approx. 80% in comparison to the formula without the improver and iodine). Compared to the formula with 2% of the improver alone, an 8% average increase was obtained with the addition of 2 ppm iodate.

Iodine doses for enrichment of wheat bakery products

Some looses of iodine added in the form of different compounds can be expected during the processing of wheat bread. When potassium iodide was added, 76% retention was determined in wheat bread after 2 day storage, and

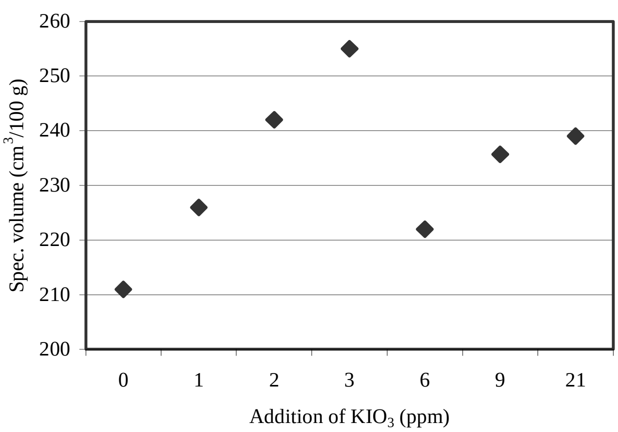

Fig. 4. Effect of KIO_3 on loaf specific volume

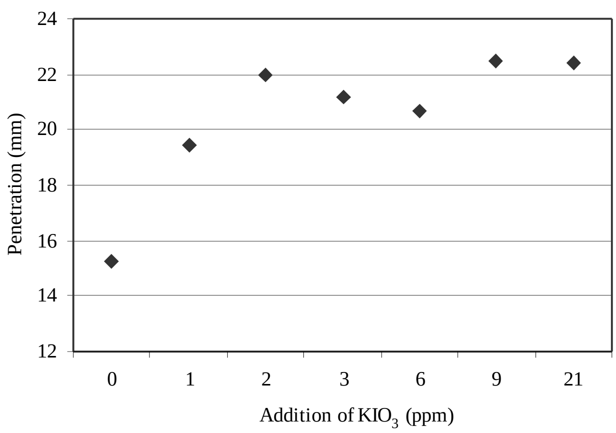

Fig. 5. Effect of KIO_3 on crumb penetration

Table 1. Effect of addition of complex commercial improver Naturback-2 and KIO_3 on specific volume of loaf and on crumb penetration depth

Addition per flour		Specific volume	Penetration
Improver (%)	KJO_3 (ppm)	(cm^3/100 g)	(mm)
0	0	239	21.5
2	0	319	28.0
2	1	334	28.5
2	2	434	28.0
2	3	313	28.5
2	6	365	29.0
2	9	311	28.0
2	21	296	27. 5

73% after 10 day storage. If potassium iodate was used, 80% and 70% retention respectively was found (KUHAJEK & FIEDELMAN 1973). Another source reported approximately 95% retention in dough before baking when potassium iodide was used (FIEDLEROVÁ 1998).

Our first determination showed 60–70% retention after the addition of the mixture of the commercial improver and potassium iodate. The result is based on a single determination only and needs verification. Yet the retention rate obtained is quite close to the results found in baked products by KUHAJEK and FIEDELMAN (1973).

Based on the results of instrumental and baking tests, the most acceptable content of iodate in flour was 2 or 3 ppm. If we consider the recommendation of the Czech law, 50% of recommended daily dose when recalculated to iodate equals 127 µg per 100 g of baked product. To supply this dose, approximately 173 µg has to be added to flour with regard to the average yield of the final product. If retention is considered approximately 65%, the content of iodate in flour should be about 2.7 ppm.

CONCLUSION

Based on the first experimental results, we can make a preliminary conclusion. Considering the processing looses, the daily recommended iodine intake values in wheat baked products can be satisfactorily supplied. Enriched bakery products can be a reliable source of iodine, especially when we take into consideration that such products are consumed daily, usually without any extreme declinations. Rheological properties of dough and the consumer quality of products can be at least slightly improved by the addition of iodate.

Acknowledgement: The authors are obliged to Lactoprot-Zeelandia Co., for full material sponsoring of the work presented.

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Received for publication December 8, 2000
Accepted for publication March 19, 2001

Souhrn

ŠPAČKOVÁ Z., PŘÍHODA J., ROVNANÍKOVÁ S. (2001): **Obohacování pšeničné mouky jodem a současné zlepšování reologických vlastností těsta**. Czech J. Food Sci., **19**: 219–223.

K řešení jodového deficitu u potravin je nejčastěji používáno obohacování jodidem draselným. V této práci bylo testováno použití jodičnanu draselného pro obohacování pekařských pšeničných výrobků. U těst používaných na běžné pečivo byly testovány reologické vlastnosti na farinografu a extensografu a bylo provedeno pokusné pečení. Vliv jodičnanu byl testován s komerčním zlepšujícím přípravkem. Dávky jodičnanu, které mají zlepšující efekty, současně umožňují krytí 50 % denní doporučené dávky jodu tak, jak poporučuje příslušná vyhláška Ministerstva zdravotnictví ČR.

Klíčová slova: pšeničné těsto; reologické vlastnosti; oxidace těsta; obohacování jodem

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