Acta Univ. Sapientiae, Alimentaria, **7** (2014) 88–95

Effect of salt forms and concentrations on the valorigraphic parameters of winter wheat flour

P. Sipos
email: siposp@agr.unideb.hu

Zs. Szilágyi
email: zsuzsanna.szil@gmail.com

M. Móré
email: morem@agr.unideb.hu

University of Debrecen, Faculty of Agricultural and Food Sciences and Environmental Management, Institute of Food Science,
138 Böszörményi St., 4032 Debrecen, Hungary

Abstract. Salt (NaCl) is a basic component of our foodstuffs. Its taste is required by customers and it has effects on the technological properties, too. Nutrition science considers it as one of the hazardous food additives due to the negative health aspects of sodium. It is especially a current topic in Hungary; the average national intake is about threefold-fourfold of the recommended value for men and twofold-threefold for women. This question is especially interesting in the case of bakery products; it is found that a significant amount of sodium intake is due to the baked product consumption. The aim of this study was to evaluate that whether the gluten network influencing the effect of the salt concentrations and forms can be measured by Valorigraph. Results show that the sodium chloride addition significantly influences the Valorigraph parameters. An increase was found in the case of dough development time and stability, while the value of softening decreased and therefore the baking value of flour improved. The different salt forms also change the readings; so, the gluten network modification effects of salt forms and concentrations can be characterized by Valorigraph test.

Keywords and phrases: winter wheat flour, Valorigraph, sodium, salt forms.

1 Introduction

Sodium chloride (NaCl) is one of our most ancient food raw materials and additives. Its role is giving taste to the food (it is one of the four general basic tastes); it is one of the first preservatives (due to its water-activity decreasing function) and in several cases it has effects on the behaviour of raw materials and therefore on their technological quality. These functions can be experienced in bakery use: the sodium chloride stabilizes the fermentation processes also during rising and baking. Saltless dough is gassy; a sour one and the bread made from it has poor texture (*Matz*, 1992). The increase in osmotic potential resulted by the salt addition significantly increases the fermentation time or makes the increase of the amount of added yeast necessary. The leaven or the indirect dough-making technology is this microbe-hindering role of salt; the fifth-sixth part of the original yeast addition is necessary for leaven bread making, but the process time increases to 6-8 hours.

Beside its effect on fermentation, salt has an important influence on gluten and dough structure. It was found that increase in sodium chloride addition decreases the water absorption of flour and increases the development time of dough while increasing its strength too (*Hlynka*, 1962; *Preston*, 1989; *Tanaka et al.*, 1967). Its main reasons are the changes in the pH and the ionic conditions of dough. The liquid phase of saltless dough has a pH around 6 and the gluten network has stable positive charges due to the weakly acidic medium, while the side-chains repulse each others, resulting in a weaker gluten network. Sodium chloride addition results in a stronger gluten structure due to the increase of pH and the decrease in positive charges. These changes can be experienced to 1.5 and 2% salt addition; a further increase in concentration hinders the dough development (*Preston*, 1981; *Danno* & *Hoseney*, 1982). On the other hand, by the appearance of Na^+ and Cl^- ions in the dough, their protein-stabilizing (non-chaotropic) character makes the proteins less hydrated, resulting less water absorption (*Cacace et al.*, 1997; *Miller* & *Hoseney*, 2008). About 35% of gluten proteins are hydrophobic and the ionic concentration and composition of the liquid phase of dough modifies their solubility as well as the hydrophobic interactions within the gluten structure (*Danno* & *Hoseney*, 1982).

The salt intake of today's people is found to be high by the nutritionists. The recommended daily intake is 5 g/day sodium chloride, but the people consume a higher (and, in several cases, much more) amount almost worldwide. Based on an international survey, the Hungarian consumers are leading in salt intake: 17 g/day is the average consumption for men and 12 g/day for

women, and the reading for children is also high (*Martos*, 2010). Salt intake reduction programmes started worldwide to decrease people's sodium increase, as significant connection was found between the intake and the occurrence of high blood pressure and cardiovascular diseases (*He & MacGregor*, 2007; *Jones*, 2008; *Satin*, 2008), and the decrease in intake results in the immediate decrease in blood pressure (*Kurtzman*, 2001). About one-third of the sodium is consumed via the bakery products (*Cauvain*, 2007) and – as this product group and other wheat-based products have significant role in the groups of staple foods (*Véha*, 2007; *Véha et al.*, 2012) – the Hungarian National Salt Reduction Programme started in 2010 prescribes decrease in the salt content of bakery products.

There are only a few products available for the substitution of salt. Generally, potassium chloride is used for this purpose, but its metallic taste in bread and its potential health risk hinder its use – it is used only to a maximum of 50% substitution for sodium chloride (*Matz*, 1992). While the effects of sodium chloride on dough and the gluten properties are widely evaluated, the effects of other salt forms are investigated much less. The aim of this study is the evaluation of the effect of salt forms and concentrations on the rheologic properties of winter wheat dough and the detailed exploration of their effects on the Valorigraph parameters.

2 Materials and method

Materials

The evaluated flour samples were BL55 ones and bought from a local supermarket. The evaluated salt forms were sodium chloride, potassium chloride, sodium acetate, potassium acetate and calcium acetate (VWR, Belgium). The ion-exchanged water used for tests was performed by a MILLIPORE water purifier (Millipore, France).

Valorigraph tests were performed by FQA-205 valorigraph (METEFÉM, Hungary). All the analyses were done in the laboratory of the University of Debrecen, Faculty of Agricultural and Food Sciences and Environmental Management, Institute of Food Science.

Methods

Valorigraph tests were performed by the MSZ ISO 5530-3:1995 Hungarian Standard. Salt solutions were prepared in 0.5; 1.0; 1.5 and 2.0% w/v%. All

the measurements were performed in two repetitions. The results were analysed by one-way analysis of variance using SPSS 15.0 for Windows statistical programme package (SPSS Inc.), while Tukey's post-hoc test was used to reveal significant differences. The tables present means and standard deviations.

3 Results and discussion

The rheologic properties measured by Valorigraph were influenced by the sodium chloride addition. The dough development time increased by the increasing salt concentration; 2% sodium chloride addition resulted in a 34%-increase regarding this value, but only the salt addition had proved to be effective statistically; this parameter was not influenced significantly by the concentration of sodium chloride, although an increasing tendency can be seen in the further results (*Table 1*). The stability also increased significantly by the salt addition and the effect of higher concentrations (1.5 and 2.0%) resulted in a statistically proved increase. In the readings of baking value, a significant increase was found again, but the water absorption capacity was not influenced by the increase of salt concentration in contrast to the references.

Table 1: Valorigraph readings of dough made from BL55 flour and sodium chloride solution

Salt concentration, %	Water absorption capacity,%	Dough development time, min	Stability, min	Baking value
0.0	64.7 ± 0.4 a	3.5 ± 0.1 a	7.3 ± 0.1 a	57.9 ± 1.5 ab
0.5	64.9 ± 0.4 a	4.1 ± 0.1 b	7.6 ± 0.1 a	55.4 ± 1.3 a
1.0	65.6 ± 0.6 a	4.1 ± 0.1 b	8.0 ± 0.3 a	61.9 ± 0.7 b
1.5	64.7 ± 0.1 a	4.6 ± 0.1 b	10.6 ± 0.2 b	68.1 ± 0.6 c
2.0	64.8 ± 0.3 a	4.7 ± 0.2 b	10.4 ± 0.4 b	65.1 ± 1.6 bc

Means marked with the same letter in the same column were not significantly different at the 5% confidence level on the basis of Tukey's test.

Similar tendencies were found in the case of potassium chloride addition (*Table 2*). The KCl addition did not influence water absorption capacity, but the increasing concentration improved the valorigraph readings significantly. The increases in dough development time, stability and baking value were remarkable and higher than the ones experienced in the case of NaCl use.

Table 2: Valorigraph readings of dough made from BL55 flour and potassium chloride solution

Salt concentration, %	Water absorption capacity,%	Dough development time, min	Stability, min	Baking value
0.0	64.7 ± 0.4 a	3.5 ± 0.1 ab	7.3 ± 0.1 a	57.9 ± 1.5 ab
0.5	64.4 ± 0.3 a	4.2 ± 0.3 abc	7.9 ± 0.4 ab	54.3 ± 1.0 a
1.0	64.3 ± 0.4 a	3.4 ± 0.2 a	9.1 ± 0.2 b	62.0 ± 0.8 b
1.5	64.0 ± 0.1 a	4.8 ± 0.4 bc	12.2 ± 0.4 c	71.5 ± 1.5 c
2.0	64.1 ± 0.1 a	4.9 ± 0.5 c	12.3 ± 0.5 c	72.7 ± 1.1 c

Means marked with the same letter in the same column were not significantly different at the 5% confidence level on the basis of Tukey's test.

The effects of sodium, potassium and calcium acetate were also negligible on the water absorption capacity readings; this parameter varied from 63.0 to 64.7% in all cases. Sodium acetate did not have a statistically proved influence on the dough development time in contrast to the sodium chloride addition, but the increasing tendency can be seen in the results (*Table 3*).

Table 3: Valorigraph readings of dough made from BL55 flour and sodium acetate solution

Salt concentration, %	Water absorption capacity,%	Dough development time, min	Stability, min	Baking value
0.0	64.7 ± 0.4 a	3.5 ± 0.1 a	7.3 ± 0.1 a	57.9 ± 1.5 a
0.5	64.3 ± 0.1 a	4.0 ± 0.7 a	10.8 ± 0.1 b	60.9 ± 0.8 ab
1.0	63.5 ± 0.7 a	3.8 ± 0.4 a	10.3 ± 1.1 ab	61.8 ± 3.7 ab
1.5	64.3 ± 0.4 a	4.3 ± 0.4 a	11.8 ± 0.3 b	66.3 ± 0.1 bc
2.0	64.0 ± 1.4 a	4.5 ± 0.7 a	12.4 ± 1.5 b	69.9 ± 1.9 c

Means marked with the same letter in the same column were not significantly different at the 5% confidence level on the basis of Tukey's test.

However, the increasing concentrations of the other two tested acetates significantly increased this parameter to a similar extent than the chlorides and the sodium acetate. The stability was influenced by the increasing acetate concentrations in statistically proved ways and the highest increase was resulted by the highest concentration of sodium acetate. All the increases are higher than the one that was experienced in the case of NaCl addition. The

baking value readings were also improved by the increasing salt concentrations and the potassium salt resulted in the highest increase (*Table 4* and *Table 5*).

Table 4: Valorigraph readings of dough made from BL55 flour and potassium acetate solution

Salt concentration, %	Water absorption capacity,%	Dough development time, min	Stability, min	Baking value
0.0	64.7 ± 0.4 a	3.5 ± 0.1 a	7.3 ± 0.1 a	57.9 ± 1.5 a
0.5	64.4 ± 2.3 a	4.0 ± 0.1 ab	9.2 ± 0.5 b	56.9 ± 3.3 a
1.0	64.7 ± 1.0 a	4.3 ± 0.4 ab	9.3 ± 0.2 b	58.7 ± 2.6 a
1.5	64.1 ± 0.4 a	4.3 ± 0.4 ab	10.5 ± 0.1 b	64.4 ± 2.2 ab
2.0	65.1 ± 0.1 a	4.5 ± 0.1 b	11.1 ± 1.3 c	71.2 ± 0.6 b

Means marked with the same letter in the same column were not significantly different at the 5% confidence level on the basis of Tukey's test.

Table 5: Valorigraph readings of dough made from BL55 flour and calcium acetate solution

Salt concentration, %	Water absorption capacity,%	Dough development time, min	Stability, min	Baking value
0.0	64.7 ± 0.4 a	3.5 ± 0.1 a	7.3 ± 0.1 a	57.9 ± 1.5 a
0.5	64.1 ± 0.7 a	3.3 ± 0.4 a	9.6 ± 0.1 ab	58.1 ± 3.5 a
1.0	64.2 ± 0.3 a	4.0 ± 0.1 ab	8.9 ± 0.6 ab	58.4 ± 0.3 a
1.5	64.2 ± 0.3 a	4.3 ± 0.4 ab	8.6 ± 1.3 ab	60.6 ± 0.9 ab
2.0	63.0 ± 0.6 a	4.8 ± 0.4 b	11.1 ±1.3 b	69.0 ± 3.3 b

Means marked with the same letter in the same column were not significantly different at the 5% confidence level on the basis of Tukey's test.

Based on our experimental results, it was concluded that all the examined salt forms had influence on the valorigraph parameters of dough: not only the sodium chloride addition improving the quality of dough but the other evaluated salt forms, too. The increasing concentrations resulted increase in the parameters (with the exception of the water absorption capacity), but the potassium salts (chloride and acetate) had the highest effects: its use in 1.5 and 2.0% concentrations resulted advances in the quality group, from B1 to A2, based on the Hungarian qualification system. Surprisingly, calcium acetate

addition also resulted in similar findings; therefore, it is not unequivocal that the added ions or the changes in pH caused by the saline are the reasons for the effects.

Acknowledgement

This research was supported by the European Union and the State of Hungary, co-financed by the European Social Fund within the framework of TÁMOP-4.2.4.A/ 2-11/1-2012-0001 'National Excellence Programme'.

References

[1] M. G. Cacace, E. M. Landau, J. J. Ramsden, The Hofmeister series: salt and solvent effects on interfacial phenomena. *Quarterly Reviews of Biophysics*, 30. (1997) 241–77.

[2] S. P. Cauvain, Reducing salt in bread and other baked products. In: D. Kilcast, F. Angus, (eds.) Reducing Salt in Foods: Practical Strategies. 283–295. *Woodhead Publishing Ltd.* (2007) Cambridge, UK.

[3] G. Danno, R. C. Hoseney, Effect of sodium chloride and sodium dodecyl sulfate on mixograph properties. *Cereal Chemistry*, 59. (1982) 202–204.

[4] F. J. He, G. A. MacGregor, Reducing salt in foods. (eds. D. Kilcast, F. Angus), *Woodhead Publishing*, (2007) 18–46.

[5] I. Hlynka, Influence of temperature, speed of mixing, and salt on some rheological properties of dough in the farinograph. *Cereal Chemistry*, 39. (1962) 286–303.

[6] J. M. Jones, Salt and blood pressure – A need to reduce levels at any age. *Cereal Foods World*, 53. (2008) 43–45.

[7] N. A. Kurtzman, Should man live by low-salt bread alone? American *Journal of Kidney Diseases*. 37. 3. (2001) 636–637.

[8] É. Martos, Európai összefogás a lakosság sóbevitelének csökkentése érdekében – nemzeti sócsökkentőprogram. *Metabolizmus*, VIII. Suppl. A, (2010) 23–24.

[9] S. A. Matz, Bakery technology and engineering. Third edition, Van Nostrand Reinhold/AVI, NY. (1992) R. A. Miller, R. C. Hoseney, Role of salt in baking. *Cereal Foods World*, 53. 1. (2008) 4–6.

[10] K. R. Preston, Effect of neutral salts upon wheat gluten protein properties. I. Relationship between the hydrophobic properties of gluten proteins and their extractability and turbidity in neutral salts. *Cereal Chemistry*, 58. (1981) 317–324.

[11] K. R. Preston, Effect of neutral salts of the lyotropic series on the physical dough properties of Canadian red spring wheat flour. *Cereal Chemistry*, 66. (1989) 144–148.

[12] M. Satin, The great salt debate. *Cereal Foods World*, 53. (2008) 9–16.

[13] K. Tanaka, K. Furukawa, H. Matrumoto, The effect of acid and salt on the farinogram and extensogram of dough. *Cereal Chemistry*, 44. (1967) 675–680.

[14] A. Véha, Correlation between the kernel structure and the quality parameters on some Hungarian winter wheat varieties. *Cereal Research Communications*, 35. 2. (2007) 1289–1292.

[15] A. Véha, P. B. Szabó, E. Gyimes, Peritec technology to reduce fusarium toxin in the milling technology. *Review of Faculty of Engineering Analecta Technica Szegedinensia*, 6. (2012) 131–136.