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Article

Use of response surface methodology to investigate the effects of sodium chloride substitution with potassium chloride on dough rheological properties

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Abstract: Bakery products are one of the main sources of dietary sodium intake of the world's population. During the last decade the sodium intake has increased worldwide and now a days the ~~WHO~~ World Health Organization recommends ~~us~~ to reduce sodium intake up to 2 g Na/day. KCl is the leading substitute for reducing sodium in bakery products. Due to this fact the main purpose of our study was to investigate the impact of sodium reduction on dough rheological properties by reformulation the dough recipe using two types of salts namely NaCl and KCl in different amounts addition in wheat flour. In order to establish their combination for obtaining optimum dough rheological properties the response surface methodology (RSM) by the Design Expert software was used. The effect of combined NaCl and KCl salts were made on mixing, viscometric and fermentation process by using Farinograph, Extensograph, Amylograph and Rheofermentometer devices. On dough rheological properties KCl and NaCl presented a significant effect ($p < 0.01$) on water absorption, stability, energy, dough resistance to extension, falling number and all Rheofermentometer analyzed values. Mathematical models were achieved between independent variables, the KCl and NaCl amounts, and the dependent ones, dough rheological values. The optimal values obtained through RSM for the KCl and NaCl salts were of0.37 gKCl/100g and 1.31 g NaCl/100 g wheat flour fact that leads to a 22% replacement of NaCl in dough recipe.

Keywords: KCl; NaCl; rheological properties; multiple criteria optimization; desirability functions.

1. Introduction

A high dietary sodium intake may leads to cardiovascular, bone demineralization and cancer diseases [1, 2]. According to the American Heart Association, the cardiovascular diseases are the leading cause of mortality globally [3].The close association between hypertension values and sodium intake is an important issue from a public health perspective. Nowadays World Health Organization (WHO) recommends ~~us~~ to not exceed a sodium consumption of 5 g per day [4] and wants to reduce sodium intake up to 2 g Na/day [5]. In addition to the beneficial effects on health, sodium reduction also contributes to an annual decrease of medical expenditures. Bread is considered worldwide to be an essential food for human nutrition. However, it might represent an important source of sodium intake. The increased consumption of bakery products increases the risk of diseases associated with sodium consumption [7,8]. The sodium sources in bakery products are provided by ingredients such as sodium bicarbonate, a baking agent, widely used in baking and sodium chloride (NaCl) which is one of the main ingredients used in the bakery manufacturing process [9].The sodium chloride additions in bakery recipe are very important from ~~the~~ a technological point of view [10]. Its reduction may leads to negative effects on technological process of bakery products and the quality of the finished products [11-14]. From the technological point of view, the sodium chloride addition increases dough strength and stability, it capacity to retain gases and at low levels yeast activity [10,11]. To bakery products NaCl increases the shelf-life due to the inhibition effect on microbial growth, it improves bread texture and its sensory properties [13,14]. Due to the effect of sodium chloride on the technological process and the quality of the bakery products it substitution in order to reduce the sodium content from the bakery products it is a problematic issue. Previous studies have shown that the potassium chloride (KCl) is the leading substitute for reducing sodium in bakery products [9,10,15-17]. Potassium chloride ~~it~~ is a natural ingredient obtained from rock and sea salts with extraction methods similar to those of sodium chloride. The effect of potassium chloride consumption in the human diet is associated with a low risk of high blood pressure and other diseases associated with it, the effect being contrary to the intake of sodium chloride [18,19]. It has an ~~intrinsic~~ salty taste but with a metallic and bitter after tastes when high levels are incorporated in bakery recipes [20]. Therefore, the complete replacement of sodium chloride in bakery products it is not recommended. It use in food products maybe only in combination with sodium chloride in order to obtain products of a high quality [10, 16]. Reducing sodium by replacing it with potassium chloride has to be done gradually because of its influence on technological process and quality of the bakery products [21]. The Response Surface Methodology (RSM) has been used in several food related papers and applications. In the literature some applications of RSM to flour, dough and bread, demonstrate its effectiveness. In particular, Cappelli et al. (2020) developed optimization charts regarding the milling process of wheat and for flour characterization [22]. Moreover, Cappelli et al. (2018) published predictive models of the rheological properties of doughs specifically developed with RSM [23].The aim of this study was to analyze the effect of partial sodium chloride substitution with potassium chloride on the technological process of the bakery products. For this purpose, we used KCl and NaCl in different combinations by using response surface methodology (RSM) in order to analyze their effect on dough rheological properties and to obtain their optimum formulation from the technological point of view.

2. Materials and Methods

2.1. Materials

Refined wheat flour (harvest 2019) was providing by the S.C Mopan S.A. (Suceava, Romania). The NaCl and KCl were purchased from the Romania market. A high quality wheat flour was used. This is confirmed by the characteristics analyzed by the Romanian and international standard methods: 0.65 g/ 100g ash (ICC 104/1), 14.0 g/100 g moisture (ICC 110/1), gluten deformation index 6 mm (SR 90:2007), 12.67 g/100g protein (ICC 105/2), wet gluten 30 g /100g (ICC106/1), falling number 442 s (ICC 107/1) [24].

2.2. Dough rheological properties during mixing and extension

In order to analyze dough rheological properties during mixing a Farinograph device (Brabender, Duigsburg, Germany, 300 g capacity) was used. The dough rheological properties during extension were analyzed using the Extensograph device (Brabender, Duigsburg, Germany). The Farinograph values analyzed through ICC method 115/1 were: water absorption (WA), dough stability (ST), dough development time (DDT) and degree of softening at 10 minutes (DS).The Extensograph values analyzed through ICC method 114/1 were: resistance to extension (R_{50}), maximum resistance to extension (R_{max}), energy (E) and ratio number (R/E)at a proving time of 135.

2.3. Dough viscometric rheological properties

In order to analyze the dough viscometric rheological properties ~~an~~ Amylograph (Brabender OGH, Duisburg, Germany) and Falling Number (Perten Instruments AB, Sweden) devices were used. Amylograph trials were performed according to ICC method 126/1: gelatinization temperature (T_g), temperature at peak viscosity (T_{max}) and peak viscosity (PV_{max}). With respect to falling number trials, the ICC method 107/1 was applied.

2.4. Dough rheological properties during fermentation

The dough rheological properties during fermentation were determined by using an Rheofermentometer device (Chopin Rheo, type F3, Villeneuve-La-Garenne Cedex, France).The fermentation parameters analyzed according to AACC method 89-01.01.were: maximum height of gaseous production (H'_m), volume of the gas retained in the dough at the end of the test (VR), total CO_2 volume production (VT) and retention coefficient (CR).

2.5. Experimental design and statistical analysis

In order to analyze the simultaneous effects of the KCl and NaCl amounts on the rheological properties of the wheat flour dough, the response surfaces methodology (RSM) was used. RSM has important application in the design, development and formulation of new products, to optimize the formulations factors [25-27] or to determine the optimum conditions for the process [28], showing the effect of the factors on the responses. ~~The RSM is one of the most popular methods for evaluating the significance of the effects of independent variables on system responses and to decide which ones may be consider in the final model [22-24].~~ Results optimization by the RSM method involved three main steps: statistical design of the experiment, ~~then~~, determination of the mathematical models coefficients and finally, prediction of the responses and checking the adequacy of the mathematical model within the design of the experiment (DOE) using the Design Expert software, trial version 12 (Stat-Ease, Inc., Minneapolis, USA). For this study two independent variables were chosen as follows: the influence of the variations of the potassium chloride amount ($A=X_1$) and sodium chloride ($B=X_2$) on the rheological parameters (dependent variables) of wheat flour dough. The experimental designs, with the real and coded values of the independent variables, are shown in Table 1.

Table 1. Real and coded values of independent variables.

used in the experimental design

Run	Real value		Coded value	
	KCl[1] (g/100g)	NaCl[1] (g/100g)	X_1	X_2
1	0.3	0.3	-1	-1
2	1.5	0.3	1	-1
3	0.3	1.5	-1	1
4	0.9	0.9	0	0
5	0.9	0.9	0	0
6	0.9	0.9	0	0
7	1.5	0.9	1	0
8	0.9	0.9	0	0
9	1.5	1.5	1	1
10	0.9	1.5	0	1
11	0.9	0.9	0	0
12	0.9	0.3	0	-1
13	0.3	0.9	-1	0

[1]KCl - potassium chloride; NaCl - sodium chloride.

The rheological parameters determined to Farinograph were: WA - water absorption (Y_1); DT - development time (Y_2); ST - stability of dough (Y_3); DS - degree of softening (Y_4). The rheological parameters determined to Extensograph were: E - Energy (Y_5); R_{50}- resistance to extension up to 50 mm (Y_6); R_{max} - maximum resistance (Y_7); R/E - (Y_8). Moreover, the Falling Number index values (Y_9) has been determined. The rheological parameters determined to Amylograph were: T_g - gelatinization temperature (Y_{10}); PV_{max} - peak viscosity (Y_{11}); T_{max} - temperature at peak viscosity (Y_{12}), H'm - height under constraint of dough at maximum development time (Y_{13}), VT - total volume of CO_2 produced during fermentation (Y_{14}), VR - volume of the gas retained in the dough at the end of the test (Y_{15}) and CR - retention coefficient (Y_{16}). In order to minimize the measurement errors of the experimental data, the rheological values obtained for the wheat flour samples with different levels of KCl and NaCl addition according to our experimental design were carried out twice. In the statistical processing their average values were used.

The predicted responses of the system ($Y_{1\ldots n}$) (Eq. 1) in factorial screening experiments have been defined by a mathematical model:

$$Y = f(X_1, X_2) = \beta_o + \sum_{i=1}^{n}\beta_i \cdot X_i + \sum_{i=1}^{n-1}\sum_{j=i+1}^{n} \beta_{ij} \cdot X_i \cdot X_j + \sum_{i=1}^{n}\beta_{ii} \cdot X_i^2 + \varepsilon \quad (1)$$

where: β_o is the constant coefficient; β_0-β_i is the linear coefficient; β_{ij} is the interaction coefficient; β_{ii} is the quadratic coefficient; n is the number of factors studied and optimized in the experiment; X_i and X_j are the coded values of the independent variables and ε is the residual associated with the experiment. The residuals associated with the experiment were used to calculate the standard deviation values for each dependent variable. The significance of the model terms is evaluated by ANOVA, which performs a comparison of the variation in the response with the variation due to random error, at the probability value (p-value) of 95%. The suitability of the mathematical models has been checked by the *F-tests* and for the accuracy of the fitted polynomial equation was determined by adjusted ~~the~~ coefficient of determination (Adjusted R^2). ~~The significant model terms were evaluated by the probability value (*P-value*) at 95% confidence interval. The *P-value* is the probability that the given statistical model is the same as or higher than the obtained results when the null hypothesis is true.~~ The non-significant coefficients were eliminated from the polynomial equations. In order to illustrate the dependence between the dependent and the independent variables, the three-dimensional graphical representation of the response surfaces was made.

3. Results and discussions

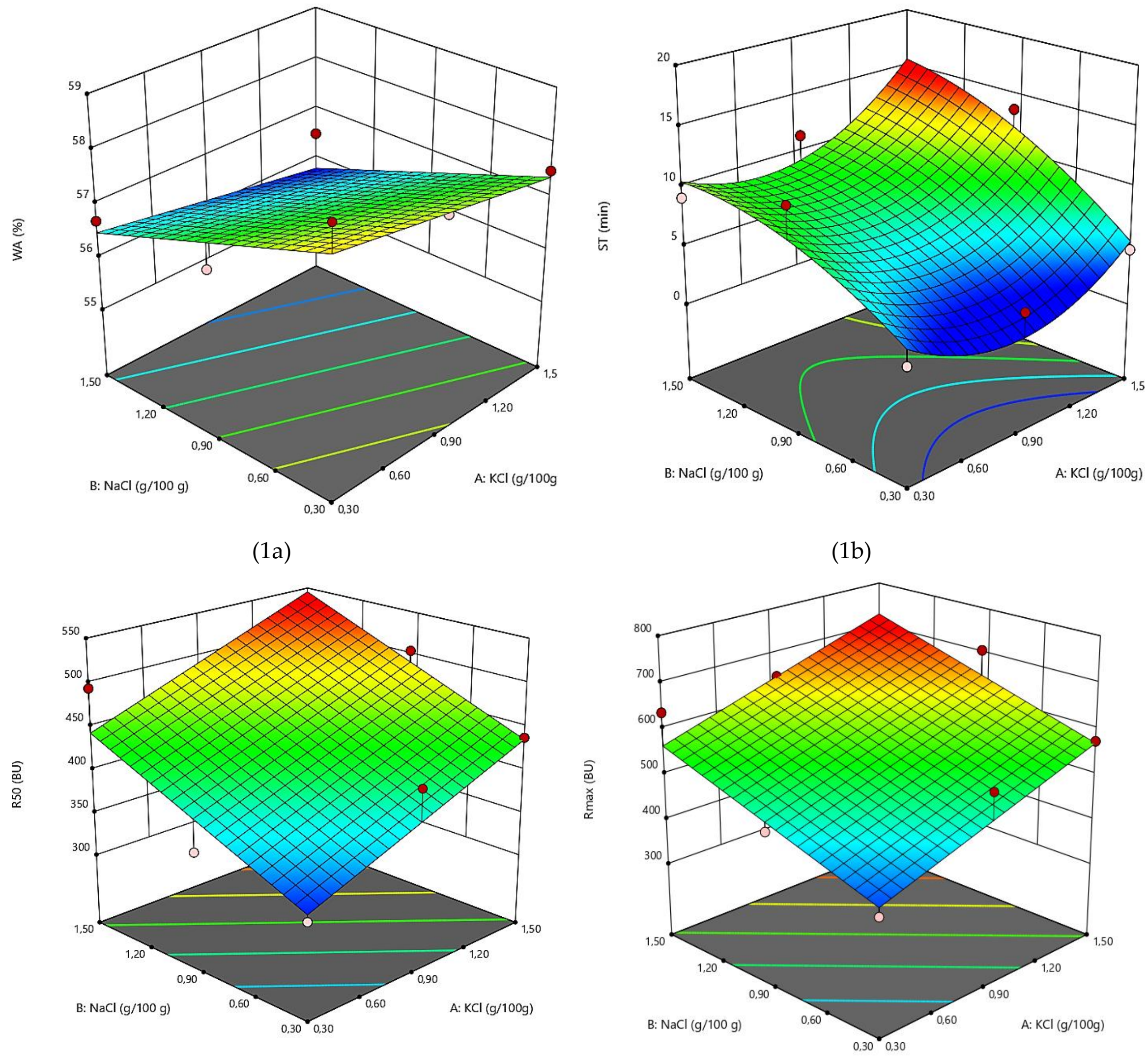
3.1. Fitting models

Following the statistical processing of the experimental data regarding the effects of independent variables on the predictive models for dough rheological properties during mixing of KCl-NaCl mixtures, the most fitting models (quadratic models)were obtained for the following parameters: water absorption (WA), dough development time (DT), dough stability (ST), degree of softening at 10 min (DS), the Falling Number value (FN), peak viscosity (PV_{max}), temperature at peak viscosity (T_{max}), height under constraint of dough at maximum development time (H'm), total volume of CO_2 produced during fermentation (VT), volume of the gas retained in the dough at the end of the test (VR) and retention coefficient (CR).

3.2. The mixing and extension rheological properties for the mixes samples

Applying the ANOVA method to the mixing and extension values, it was observed that KCl has a significant effect ($p < 0.01$) on the rheological parameters as E, R_{50}, R_{max}, R/E, Tg, H'm, VT, VR, CR, while NaCl has a significant effect ($p < 0.01$) on WA, ST, E,R_{50}, R_{max}, R/E, PV_{max}, H'm, VT, VR.

As it may be seen from Figure 1a both types of salt leaded to a significant decreased ($p < 0.01$) of WA value. This may be due to the fact that in the presence of salt ions the electrostatic repulsion between gluten molecules are reduced as a consequence of their ability to partially shields the present charges between molecules. Thus, the gluten proteins aggregate in a higher extent due to the increase level of hydrophobic interactions between molecules fact that leads to a decrease of the water uptake ability [2].



(1a) (1b)

(1c) (1d)

Figure 1. The graphical representations of the Farinograph and Extenograph parameters: 1a. water absorption (WA); 1b. stability of dough (ST); 1c. resistance to extension up to 50 mm (R_{50}); 1d. maximum resistance to extension (R_{max}).

From the two types of chloride salts it seems that NaCl presented a highly significant effect ($p < 0.01$) on WA value than KCl salt ($p < 0.01$). These results were similar with those reported by Tuhumuryet al. [32]; Jeckle et al. [2] which concluded that the intensity of chloride salts on WA value depends on cation position in Hofmeister series K^+ being positioned before Na^+. A decrease of WA value with the increase of the salt level addition has also been reported by different researchers [5,9,33-36].

The graphical representation of dough stability (ST) value in relation with the level of KCl and NaCl addition is shown in Figure 1b.It may be seen a significant increase ($p < 0.01$) of this value with the increase level of the both independent variables addition. This indicates a strengthening effect of chloride salts on wheat dough. Gluten proteins presents a surface hydrophobicity and contains almost 35% hydrophobic amino acids which promotes a protein aggregation in a more extent way when chloride salts are incorporated [9] leading to a higher dough stability. A significant increase of dough stability with the addition of chloride salts in wheat flour has also been reported by different researchers [2, 12, 37].

The effects of chloride salts on the Extenograph parameters curve are similar. According to Tuhumury et al. [32] this may be due to the fact that Na^+ and K^+ are nearby situated in the Hofmeister series and that way they exhibit similar effects on wheat dough properties. All the models for the

Extenograph values were linear. Both independent variables presented a significant positive effect (*p < 0.01*) on energy (E), resistance to extension (R_{50}), maximum resistance to extension (R_{max}) and ratio number (R/E). The effects of chloride salts on Extensograph values are related to their effect on gluten proteins. Their strengthen effect on dough due to the increase amount of hydrophobic interactions between molecules conducted to an increase value of E, R_{max}, R_{50} and R/E. These results were similar with those reported by McCann and Day [33]; Miller and Hoseney [9]; Tuhumury et al. [32]; Ortolan et al. [38] which concluded that chloride salts increased the resistance to extension as it may be seen in Figures 1 c,d.

3.3. The viscometricrheological properties of the mixes samples

The effect of NaCl and KCl addition in wheat flour on dough viscometric properties, expressed as their corresponding regression coefficients and models, are shown in Table 2. From model analysis the most significant models were those for quadratic model (*Adjusted* R^2=0.82) Falling Number value (FN) followed by those for quadratic model (*Adjusted* R^2=0.63), peak viscosity (PV_{max}) and 2FI model (*Adjusted* R^2=0.63) for gelatinization temperature (T_g) which was less significant (Table 3).

Table 2. Effects of independent variables, expressed as their corresponding coefficients on the predictive models for dough rheological properties during mixing of KCl-NaCl mixtures.

Factors[b]	Parameters							
	Farinograph				Extensograph (proving time 135 min)			
	WA(%)	DT (min)	ST (min)	DS (UB)	E (cm^2)	R_{50}(BU)	R_{max}(BU)	R/E
Constant	56.75	1.55	6.85	54.86	106.54	439.62	566.85	4.11
A	-0.35**	0.0167	1.55*	0.666	14.33***	51.00***	81.83***	0.57***
B	-0.80***	-0.05	4.07***	-5.67**	15.00***	54.67***	78.67***	0.50***
A x B	0.22	0.025	1.00	4.00	-	-	-	-
A^2	0.019	0.319***	3.78**	-10.52**	-	-	-	-
B^2	0.37	0.019	-1.67	11.48**	-	-	-	-
AdjustedR^2	0.76	0.70	0.75	0.60	0.74	0.82	0.79	0.79
p-value	0.0072***	0.031**	0.0079***	0.0355**	0.0005***	<0.0001***	0.0002***	0.0005***

[a] Significant at p < 0.01***, at p < 0.05**, at p < 0.1*.

[b] A - KCl (g/100g); B - NaCl (g/100g); Adj. R^2 is measure of fit of the model.

WA – water absorption; DT – development time; ST – dough stability; DS - degree of softening; E - Energy; R_{50} – resistance to extension up to 50 mm; R_{max}- maximum resistance, R/E –ratio number.

No significant model was obtained for T_{max}. Similar results were reported by Samutsri and Suphantharika [39] who concluded that different types of chloride salts did not presented any significant effect on pasting temperature on starch from rice. A positive effect on all viscometric properties was provided by the linear regression coefficients, suggesting that the increase levels of NaCl and KCl addition in wheat flour will lead to an increase in the viscometric values as it may be seen from Figure 2.

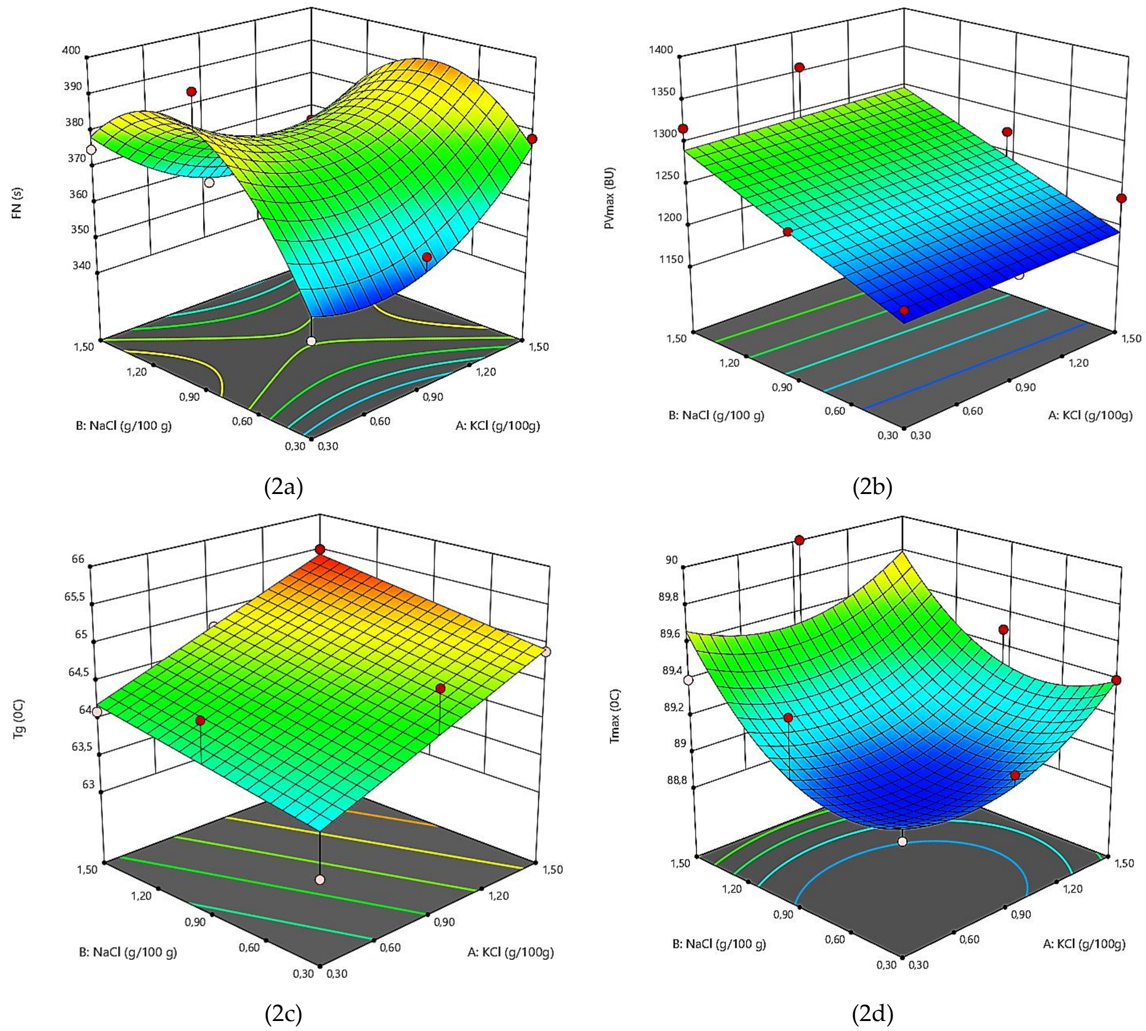


Figure 2. The graphical representations of the Falling Number and Amylograph parameters: 1a. Falling Number value (FN); 1b. peak viscosity (PV_{max}); 1c. gelatinization temperature (T_g); 1d.temperature at peak viscosity (T_{max}).

The increase of the FN and PV_{max} values with the increase of the NaCl and KCl addition (Figures 2a,b) may be due to the action of chloride salts on the protein part from the amylases structure. This fact reduces the activity of these enzymes with influence on dough rheological properties.

Previous studies have shown that in the optimal range of pH activity of amylases, the chloride salts favor their activity in dough system, whereas outside of the pH range, it reduced its activity due to the shielding effect of the reactive groups of enzymes by the ions from the system as H^+, Na^+, K^+, Cl^- [40]. In general, wheat flour has a pH between 6.0-6.8, fact that makes it ~~her~~ slightly acidic and even close to the neutral pH value. Chloride salts presents an alkaline pH. Therefore, a mix between chloride salts and wheat flour will lead to higher pH values. In Amylograph and Falling Number methods wheat flour is mixed with distillated water with a pH value around 7.00 and different levels of chloride salts. Therefore, the mixes formed ~~from~~ of wheat flour, distillated water and chloride salts will present pH values outside the optimal range of pH amylases activity which is around 5.2÷5.4 value [41]. Due to the alkaline pH of chloride salts the pH mixes analyzed to Amylograph and Falling Number will be even more outside of the optimal range of amylase activity with the increase level of chloride salts addition. Therefore, the amylases activity from the mixes from wheat flour, distillated water and chloride salts will decrease with the increase level of chloride salts addition. This fact leads to an increase in PV_{max} to the Amylograph device and to FN value to the Falling Number device which expresses α-amylase activity [42,43].

For T_g value a positive effect was provided by KCl and NaCl as it may be seen in Figure 2c this data being similar with those reported by different researchers [44-46]. This behavior are due to the fact that this types of chloride salts decreased solubility of hydrophobic chains and enhanced water structure. When NaCl and KCl are incorporated in wheat flour dough it decreases water activity and increases the energy for physical and chemical reactions which involves water fact that delays the starch gelatinization process [5,31,45].

3.4. The fermentation rheological properties of the mixes samples

All the dependent variables analyzed through Rheofermentometer parameters was significantly affected ($p< 0.01$) by the levels of NaCl and KCl addition in wheat flour. Quadratic models (Table 3) for Rheofermentometer values showed a significant effect of the linear terms of NaCl and KCl with an highly coefficient of determination (R^2) which varies mostly between 0.70 to 0.91.

Table 3. Effects of independent variables, expressed as their corresponding coefficients on the predictive models for dough rheological properties during fermentation, gelatinization properties and α-amylase activity of KCl-NaCl mixtures.

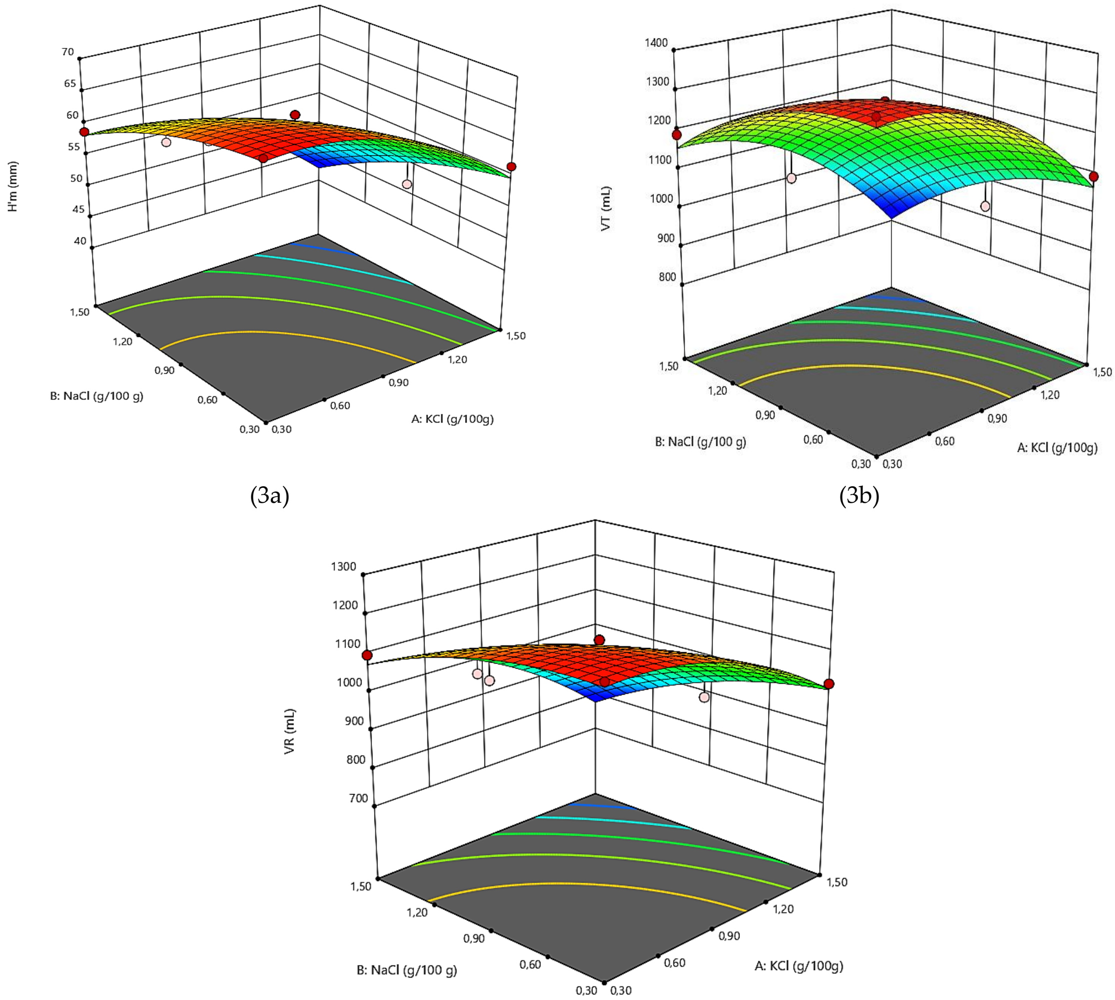
	Parameters							
Factors[b]	**FN (s)**	**Tg (^{0}C)**	**PV_{max} (BU)**	**T_{max} (^{0}C)**	**H'm (mm)**	**VT (mL)**	**VR (mL)**	**CR (%)**
Constant	378.52	64.56	1221.66	89.00	61.95	1251.93	1117.07	89.28
A	1.50	0.62***	3.33	0.1167	-7.35***	-159.50***	-124.00***	2.12***
B	2.83	0.25*	52.67***	0.25	-5.58***	-115.33***	-88.00***	1.62**
A x B	-10.25**	-0.1	-21.25	-0.05	-0.6750	-15.25	-24.00	-0.45
A^2	12.19**	-	14.21	0.1879	-4.38**	-95.26**	-63.24**	2.22**
B^2	-23.81***	-	29.21	0.2879	-1.78	-61.76	-40.24	1.42
Adjusted R^2	0.82	0.63	0.633	0.40	0.90	0.87	0.91	0.75
p-value	0.0028***	0.0071***	0.0143**	0.1193	0.0004***	0.0008***	0.0003***	0.0073***

[a] Significant at $p < 0.01^{***}$, at $p < 0.05^{**}$, at $p < 0.1^{*}$.

[b] A - KCl (g/100g); B - NaCl (g/100g); Adj. R^2 is measure of fit of the model.

FN - Falling Number; Tg - gelatinization temperature; PV_{max} - peak viscosity; T_{max}- temperature at peak viscosity; H'm - height under constraint of dough at maximum development time; VT - total volume of CO_2 produced during fermentation; VR - volume of the gas retained in the dough at the end of the test; CR - retention coefficient.

The contours plots from Figure 3 for the Rheofermentometer values showed that the maximum height of gaseous production (H'm), total CO_2 volume production (VT) and volume of the gas retained in the dough at the end of the test (VR) significantly decreased ($p< 0.01$) with an increase in KCl and NaCl levels addition in wheat flour. The retention coefficient value (CR) increased with the increase level of KCl and NaCl addition in wheat flour.



(3a) (3b)

(3c)

Figure 3. The graphical representations of the Rheofermentometer parameters: 3a. maximum height of gaseous production (H'm); 3b. total CO_2 volume production (VT); 3c. volume of the gas retained in the dough at the end of the test (VR).

H'm is strongly affected by the yeast fermentation and also by the dough structure [2, 47].Thus, by chloride salts addition the gluten network become more strength and less extensible fact that will lead to a lower dough expansion during fermentation. Also, chloride salts represses yeast activity by its osmotic pressure effect [13], fact that will lead to less CO_2 production and lower H'm values as ~~it~~ may be seen from Figure 3a. The decrease of the H'm together with the increased level of KCl and NaCl addition is in agreement with many previously made studies which reported that the addition of any type of chloride salts decreased the values of Rheofermentometer parameters [2, 9, 13, 34, 46].

The repressing effect of salt on yeast leads also to lower VT values as it may be seen from the Figure 3b and as a consequence, to lower VR values [44]. However, contrary to the negative effect of NaCl and KCl on H'm, VT and VR values it's presented a significantly ($p< 0.01$) positive one on CR value. This behavior is due to the gluten network improvement which becomes more strength by chloride salt addition and with a higher ability in retaining the gas released by fermentation [48].

3.5. Optimization of the KCl and NaCl formulation

An important objective of this research was to calculate the optimal values of the rheological parameters of the dough. For this purpose the Derringer desirability function (Equation 2), a multi-criterion decision-making method, was used [49, 50]. The optimization process using the numerical method by the Design-Expert was performed.

$$D = \left(d_1^{r_1} \cdot d_2^{r_2} \cdot \ldots \cdot d_n^{r_n}\right)^{\frac{1}{\Sigma r_i}} \quad (2)$$

where: $d_1, d_2, \ldots, d_n$ are the desirability indices for each dependent variables and $r_1, r_2, \ldots, r_i$ are the relative importance of the dependent variables. A non-zero value of *D* from zero implies that all responses are in desirable range and for a D value close to 1 the response values are close to the desirable values. By applying the desirable function methodology, the optimal values of the independent variables were obtained.

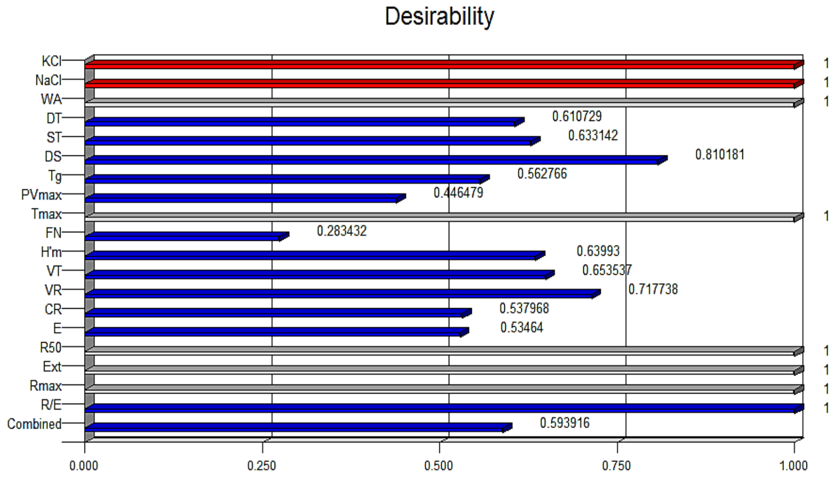


Figure 4. Desirability function scores for the independent variables (A and B) and the studied dependent variables.

The optimum values of the amount of KCl are 0.37g/100g wheat flour, and the optimal amount of NaCl is 1.31 g/100g wheat flour. For these optimal solutions, the optimal values for the dependent variables were obtained: WA - 56.626%, DT - 1.805 min., ST - 10.471 min., DS - 43.454 UB, Tg - 64.149 ^{0}C, PV_{max} - 1281.438 BU, T_{max} - 89.513OC, FN - 383.978 s, H'm - 59.714 mm, VT - 1192.988mL, VR - 1098.555mL, CR - 92.027 %, E - 104.475 cm^2, R_{50} - 433.33 BU, Ext - 138.923 mm, R_{max} - 549.359 BU and R/E - 3.95with a desirable function score of 0.594.

3.6.Strategy approach for bakery products reformulation for sodium amount reduction related to our KCl-NaCl optimum values

Backery products are one of the main dietary sources of salt in the most European countries. It seems that the highest consumtion of bakery products occurred in the Eastern and Central Europe. In Northen Europe other products such of those of animal origin are the most consumed ones being the main dietary sources of salt intake. Nowdays the daily salt intake in most EU countries ranges from 7 to 13 g per day (with the lowest intake values in Northen Europe countries and the highest ones in Central and Eastern countries)fact that exceed the World Health Organization recommandation data [51]. Due to this fact many European countries recommands foods reformulation in order to reduce the salt content from itsand runs many nutrition action plansfor this purpose. For exemple, the Ministry of Health from some EU countries recommended reducing salt in bakery products with 15% up tp 2015 in Austria, with 10% up to 2012 in Italy, with 20% up to 2014 in Spain, etc. [16]. The maximum target for the salt level that want to be achived varies from one country to another. For exemple of 2.35% for bread products from Hungary from 2019and of 1.4% for bakery products from Spain. These high differences between EU counties targets are related to the usual levels that normally exist in this countries in bread products. So, for exemple the level of salt from popular Hungarian bakery products are arround of 3% [52] whereas in Spain the mean salt content from the bakery products are arround of2% [53]. Besides the fact that salt reduction in bakery products affect its tehnological process, fact developed in a quite large extense during this study, it also affect bakery products quality. According to our study, a 22% replacement of NaCl in dough recipe through KCl is the optimum one in order to obtain bakery products of a very good quality. According to the data from the international literature a 20% sodium reduction in bakery products did not affected bread quality from the sensory (including taste) point of view [51]. Regarding the use of KCl as a NaCl substitute previous studies has shown that it addition up to 20-30% did not affected the taste of the bakery products. However, levels higher than 30% of KCl addition in wheat flour led to a metallic and bitter aftertastes fact that not recommend it in bread making [10]. Therefore, our results are favorable for obatining very good bakery products from technological and sensory point of view. As we mentioned before, nowdays different countryes are trying gradual reduction of sodium levels from different foodstuffs. But this reduction is limitated due to the consumers acceptance who are not willing to give up to their eating habits especially from the sensory point of view. The use of KCl as an ingredient to reduce sodium in foodstuffs is expected to increase in the coming years [54]. This use it is also in accordance with the many years recommendations of the WHO that people must reduce Na intake and increase K intake. Despite WHO rigurous recommandation very little progress are being made worldwide in this dirrection [55]. Our optimum values obtained through RSM methodolody reduces with 22% the sodium content from the bread receipe and increased the K level through KCl addition to arround 200 mg/100 g bread. Our study proposes a formulation which lead to bakery products of a good quality in accordance with WHO recommandation of sodium reduction intake from foodstuffs. Also, the propose of sodium reduction is by NaCl substitution with KCl, a natural ingredient which is also an agreed one by World Health Organization.

4. Conclusions

According to the obtained data, it seems that both chloride salts has a similar effect on dough rheological properties. With respect to mixing properties, both types of salts presented a positive effect on dough stability, ~~and~~ to the energy, and to dough extensibility ~~resistance to extension~~ values. During heating the chloride salts increased dough viscosity, fact reflected in an increase of PV_{max} and FN values. During fermentation the both chloride salts decreased the H'm, VT, VR Rheofermentometer values and increased the CR value. The mathematical models obtained for the response variables were significant ~~ones~~ with a high values of Adjusted R^2>0.70 (except for DS, PV_{max} and T_{max}), *p-value*<0.05 (except for T_{max}) showing for most dependent variables no lack of fit. The optimum values, obtained with the numerical method, were for KCl - 0.37 g/100g wheat flour and for NaCl - 1.31 g/100g wheat flour. The use of the potassium chloride as a substitute of sodium chloride in bakery products has a double advantage, namely the reduction of sodium content as well the increase of potassium amount from the final products. Our optimum values obtained through RSM methodology lead to the best technological parameters and also reduced the amount of sodium from the bakery products with 22%, a decreased level that according to the international literature data did not affects the sensory characteristics of the food products.

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