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THE EFFECT OF REDUCING THE QUANTITY OF SALT ON THE QUALITY AND ACCEPTABILITY OF GRISSINI

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Abstract. The article proposes the technology of obtaining grissini type salt-free bakery products. Research has been carried out on reducing the salt content and replacing the water with fermentation products as kefir, whey, and sour borscht, in order to reduce the effect of the lack of salt on the product quality. The results showed that the complete exclusion of salt from the recipe had a negative effect on the dough stability, physicochemical properties and organoleptic characteristics of the baked products. Partial or total omission of salt resulted in higher dough rise ability and lower moisture content in the final product. Grissini made according to the classic recipe with salt, registered high appearance and sensory properties, while reducing the salt content results in products with a less pronounced crust and taste. The use of kefir, whey and sour borscht as water substitutes in the recipe contributed to the improvement of the chromatic parameters, as well as the physicochemical indicators of the baked grissini. However, consumers appreciated less the samples with the addition of kefir and whey. These samples being distinguished by a specific taste and smell, in some extent unusual for panelists. At the same time, grissini based on sour borscht were highly appreciated. According to the results, the sample with sour borscht without added salt recorded similar characteristics to the control sample, but in order to align it with national standards in terms of physicochemical indicators, the dough fermentation period needs to be revised.

Keywords: *acidity, grissini, kefir, sour borscht, whey.*

Rezumat. Articolul propune tehnologia de obținere a produselor de panificație de tip grissini fără sare. Au fost efectuate cercetări privind reducerea conținutului de sare și înlocuirea apei cu produse de fermentare, precum chefirul, zerul și borșul acru pentru a reduce impactul negativ al lipsei de sare asupra calității produsului. Rezultatele au arătat că excluderea completă a sării din rețetă influențează negativ atât proprietățile stabilitatea aluatului, cât și proprietățile fizico-chimice și calitățile organoleptice ale produsului copt. Omiterea parțială sau totală a sării a dus la o capacitate de creștere a aluatului mai mare și un conținut mai scăzut de umiditate în produsul final. În cazul grissinilor fabricate după rețeta clasică cu sare, aspectul și caracteristicile senzoriale au fost apreciate la cel mai înalt nivel, în timp ce diminuarea conținutului de sare duce la obținerea produselor cu crustă mai slab pronunțată și gust mai puțin evidențiat. Utilizarea chefirului, zerului și borșului acru ca înlocuitori ai apei în rețetă a contribuit la îmbunătățirea parametrilor cromatici ai grissinelor. Cu toate acestea, probele cu adaos de chefir și zer au fost mai puțin apreciate de consumatori, remarcandu-se printr-un gust și un miros specific, într-o oarecare măsură neobișnuit pentru paneliști. În același timp, grissini pe bază de borș acru au înregistrat valori similare apreciere înaltă chiar și în comparație cu cele clasice. Conform rezultatelor analizei senzoriale, proba cu borș acru fără adaos de sare a înregistrat caracteristici similare cu cele pentru proba de control, dar pentru a o alinia standardelor naționale în ceea ce ține de indicatorii fizico-chimici, perioada de fermentare a aluatului necesită a fi revizuită.

Cuvinte cheie: *aciditate, grissini, chefir, borș acru, zer.*

1. Introduction

Currently, it is relevant to expand the range of food products for preventive and therapeutic nutrition, which help to increase the duration and improve the human life quality. In ancient times, before access to salt sources, the daily consumption level was low (0.1 - 1.0 g/day). Nowadays, eating habits have changed substantially. Salt consumption differs from region to region and averages between 8.75 and 10.5 g/day [1]. The sodium content of processed foods is far above the norm, and the consumer cannot control them. Approximately 15% of dietary sodium is found in foods, and ~71% is added during food processing. Dietary sodium exists in a variety of chemical forms, such as sodium chloride (table salt), sodium bicarbonate and sodium glutamate that is a flavor enhancer found in processed foods. The human body, predetermined by evolution to conserve salt, could not adapt to increased salt intake. This is reflected in the growing number of people with hypertension and cardiovascular disease (CVD) and is putting pressure on the health care system [2].

Increased salt intake causes significant long-term complications that have physical, mental, social and economic consequences [3]. It causes and develops a range of noncommunicable diseases, including high blood pressure. The restriction of sodium in many treatments has shown beneficial effects, for these reasons it has become an adjunct therapy in several diseases involving high blood pressure, kidney disease, CVD, liver cirrhosis, etc. [4, 5].

According to World Health Organization (WHO) recommendations (5 g/day), adult salt intake in the Republic of Moldova is twice the maximum dose [6]. WHO target in Global Plan of Action to Support Government Efforts to Eliminate Noncommunicable Diseases is to reduce global salt consumption by 30% by 2025 [7]. For these reasons, the WHO has created several recommendations for reducing salt consumption among the population, which could lead to an additional year of healthy living for lower costs than the average annual income in low- and middle-income countries. One solution in this direction could be cooperation with industrial sectors to improve the quality and affordability of low-salt foods [8].

Bakery products are an essential source of salt for the human body. According the food pyramid, bread is consumed in large quantities, most often even 2-3 times a day, especially among Moldovans. The traditional custom of greeting guests with bread and salt demonstrates that the Moldovan people consume these two products in excessive quantities. According to an annual publication by the National Bureau of Statistics of the Republic of Moldova, the energy value of a person's average daily food consumption in 2016 was 2441.7 kcal, the share of energy of bread and bakery products being 41.0%. The annual consumption of bread and bakery products was on average 116.8 kg/person, with significant variations from 126.8 kg/person, which is equal to 320 g/day [9].

Considering the high bread and respectively high salt consumption of the population of the Republic of Moldova, a prospective solution would be to create bakery products with low salt content. However, salt reduction has a significant effect on dough formation, for example dough rheological properties, and final product quality. Several studies mention that the optimal salt content in the dough composition of a bakery product is 1 – 2 % related to flour weight [10 – 12].

However, according to Carcea et al. (2020), quantities of salt above 1.5% related to flour weight are unnecessary to improve breadmaking quality of flours [13].

Adding salt to the dough decreases the flour's ability to absorb water, due to its dehydrating action on gluten. On one hand, this fact increases the dough development time. On the other hand, the addition of salt enhances the dough resistance, elasticity and extensibility.

McCann & Day (2013) explain this fact by the ability of salt of increasing the non-covalent interactions of the gluten, which results in the formation of a fibrous network structure [14]. Having a strong gluten network in bakery products, especially in the layered or leavened dough, is imperious because it ensures the entrainment of gas bubbles in the dough and their retention during fermentation and baking [11].

Thus, reducing or eliminating salt content from bakery products recipes can cause negative effects on the gluten network formation and dough rheological properties, influencing this way and some physical characteristics of the final product (volume, crumb structure, texture, etc.).

In a dough composition, salt inhibits yeast growth causing a decrease in their activity, leading to lower CO_2 production [15]. Salt also inhibits the activity of flour amylolytic enzymes that liberate maltose (a fermentable sugar) outside their optimal pH range [13, 16]. In the dough without salt, the yeasts activate intensely, consuming a large amount of sugars, and when placed in the oven, the dough no longer contains sufficient amounts of reducing carbohydrates to form sufficient melanoidins to confer a ruddy color to the final product's crust [17].

The aim of the research was to develop the technology of a salt-free bakery product and at the same time to replace the liquid phase with other products, which would reduce the negative effect of lack of salt on the product quality.

2. Materials and Methods

2.1. Materials

The raw materials used to prepare salt-free grissini were taken from the classic recipe [18], which involves the use of premium wheat flour [19], water [20], salt [21], sugar [22], bakery yeast (*Saccharomyces Cerevisiae*, press form) [23], sunflower oil [24], eggs [25] and sunflower seeds [26] were used for decoration. Kefir (2.5 % fat) [27], whey and sour borscht [28] were used in order to replace the water in the experimental samples.

2.2. Methods

Samples preparation

In this research the salt amount in the grissini's formulation was reduced to 50, 25 and 0 %. In the salt-free grissini recipe, the water was totally replaced with fermentation products such as kefir, whey and sour borscht. The purpose of replacing the water with the respective products is to provide an optimal salty taste and the appropriate texture. According to Plessas et al. (2005), kefir grains, besides providing nutritional value, contribute also to the extension of bakery products shelf life [29].

The main ingredients and the used amounts are presented in table 1. For each of the basic and auxiliary raw materials, preparatory operations were: sifting (for flour) in order to remove impurities but also for flour aeration, dosing (for salt, sugar, yeast), washing and disinfection with the required solutions (for eggs) in order to prevent infection with Salmonella or other pathogenic microorganisms. It was prepared the 20±1 % salt solution and 50±2 % sugar solution. The pressed bakery yeast was dissolved in water in a 1:3 ratio. The dough with a moisture content of 37.0 ±1 % was prepared applying the straight dough method. In order to ferment, the dough was left for 120±10 minutes at a temperature of 31±1 °C, rolled out and molded in the form of sticks (length -150 mm; width -10-15 mm), left for 25±2 minutes for proofing at a temperature of 41±1 °C and relative humidity 83±2 %. On the surface, the grissini were covered with eggwash and sprinkled with sunflower seeds that naturally have a certain sodium content, thus highlighting the taste of the products and at the same time compensating for the lack of salt. The products were baked in a preheated oven at 220±2 °C for 10±1 minutes.

Table 1

Grissini formulas

Raw material	Control	$G_{50\%salt}$	$G_{25\%salt}$	$G_{0\%salt}$	KG	WG	SBG
Wheat flour, g	100	100	100	100	100	100	100
Water, g	38.3	37.9	37.7	37.4	-	-	-
Kefir, g	-	-	-	-	45	-	-
Whey, g	-	-	-	-	-	40	-
Sour borscht, g	-	-	-	-	-	-	39
Salt, g	1.5	0.75	0.37	0	0	0	0
Bakery yeast (pressed form), g	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Sugar, g	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Sunflower oil, g	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Sunflower seeds, g	50	50	50	50	50	50	50
Eggs, g	20	20	20	20	20	20	20

Note. $G_{50\%salt}$ – grissini with 50% salt; $G_{25\%salt}$ – grissini with 25% salt; $G_{0\%salt}$ – grissini with no added salt; KG - kefir grissini (no added salt); WG - whey grissini (no added salt); SBG – sour borscht grissini (no added salt).

Dough Raising Capacity (DRC) was evaluated acording to Hamad et al. (2005), by assessing the volume of the dough during the fermentation process, using Eq. (1). The grissini dough was transferred to a 100 mL graduated cylinder and initial volume of the dough was noted down. The dough volume rise was noted after 40 minutes [30].

$$DRC\ (\%) = \frac{V_1 - V_0}{V_0} \times 100, \quad (1)$$

where: V_0 - volume of the dough before fermentation.
V_1 - volume of the dough after 40 minutes of fermentation.

Determination of grissini physicochemical indicators

Moisture content was determined by drying the samples in an oven at 130±2 ° C during 45 minutes, according to ISO 24557:2009 [31].

Total titratable acidity was determined according to AACC 02-31.01 [32].

Salt content was estimated by measuring chloride ion concentration, according to ISO 9297:1989 (Mohr's method) and mentioned by Jafri et al. (2017) [33].

Color evaluation. Grissini's crust color was analyzed by using a Minolta Chromameter as in Giannone et al. (2018). Color parameters L^* (*lightness*), a^**(redness)* and b^**(yellowness)* were determined [34]. In order to describe the color change, in addition to the L^*, a^* and b^* values, according to the equations (2) and (3), the following indicators were calculated [34, 35].

- ✓ brown index – *BI* (the higher it is, the more intense is the crust's brown color):

$$BI = 100 - L \quad (2)$$

- ✓ total color difference – Δ*E*

$$\Delta E = \sqrt{(L_0^* - L^*)^2 + (a_0^* - a^*)^2 + (b_0^* - b^*)^2}, \quad (3)$$

where: L_0^*, a_0^*, b_0^* – color parameters of control sample.
L^*, a^*, b^* – color parameters of reduced salt and salt free grissini.

Sensory analysis. Food sensory evaluation measures and interprets people's reactions based on sight, smell, touch, taste and hearing. 15 specialists in the food industry field aged 22-60 years, were selected as panelists that performed sensory assessment of grissini sticks, using a 5-point scale ranging from 0 ("dislike extremely") to 5 ("like extremely") [36].

Consumer test was performed according to Pasqualone et al. (2019). A test involving 50 habitual bakery products consumers (25 male and 25 females, enrolled among students and employees of Technical University of Moldova, aged from 20 to 60 years old) was performed in order to rank preferences concerning the salt content and taste of grissini. Each consumer was offered samples of all types of prepared grissini, a glass of water and a tasting sheet. Thus, each consumer had to make a top of the 7 samples of grissini, with the qualifications: the most appreciated (score = 1), to the least appreciated (score = 7) [35].

Statistical analysis. All experiments were performed in triplicates. The results are given as mean ± standard deviation (SD). The data were statistically analyzed by ANOVA and Tukey tests (α = 0.05).

3. Results and Discussion

Effect of salt reduction on dough raising capacity

In this research, the dough samples were prepared with water, kefir, whey, and sour borscht. Each of these raw materials has a different chemical composition and nutritional value, so the fermentation process took place differently in each of them.

The table below shows the results of the dough rising (%) capacity at different time periods (table 2).

Table 2

Grissini dough rising capacity, %

Sample	Time, min				
	0	10	20	30	40
Control	n.d.	36.2±0.2[ab]	54.5±0.6 [ab]	78.2±0.6[b]	96.4±1.4[a]
$G_{50\%salt}$	n.d.	30.4±0.6[a]	50.6±1.0[a]	70.8±1.4[a]	100.2±2.2[a]
$G_{25\%salt}$	n.d.	40.4±0.2[b]	60.8±0.8[b]	92.7±2.0 [c]	106.2±1.4[b]
$G_{0\%salt}$	n.d.	52.2±0.6[c]	80.2±1.2 [d]	110.2±2.1[e]	140.6±3.1[e]
KG	n.d.	40.6 ±0.1 [b]	70.6±0.6 [c]	94.3±1.3[c]	122.8±2.6[c]
WG	n.d.	42.4±0.3[b]	60.8±1.2 [b]	100.5±1.7[d]	126.3±2.4[d]
SBG	n.d.	46.8±0.5[bc]	70.4±0.7 [c]	104.8±1.9[de]	121.5±2.5[c]

Note: $G_{50\%salt}$ – grissini with 50% salt; $G_{25\%salt}$ – grissini with 25% salt; $G_{0\%salt}$ – grissini with no added salt; KG - kefir grissini (no added salt); WG - whey grissini (no added salt); SBG – sour borscht grissini (no added salt). n.d. – not determined. Results are expressed as mean ± standard deviation, insignificant ($p > 0.05$), in each column different letters ([a-e]) mean significant differences ($p < 0.001$).

The largest increase in volume was recorded for the grissini sample prepared on water, without added salt. In the first 10 minutes, the volume of the sample increased by 52%. The samples prepared on water with a reduced salt amount ($G_{50\%salt}$ and $G_{25\%salt}$) reached these values only after 20 minutes.

The presented data show that the dough samples prepared with salt addition started to rise more slowly in volume. This can be explained by the fact that salt slows down the activity of yeast in bread dough, by diverting the water from yeast cells. Struyf et al. (2017) which states that salt's presence in wheat flour dough induces both osmotic and ionic stress to the yeast cells reported similar results [39]. At the end of fermentation, the dough samples prepared on kefir, sour borscht, and whey basis, reached similar volumes to the salt free sample. It should be noted that after more than 40 minutes of fermentation, the KG, WG and SBG samples recorded large volumes with very large bubbles of gas, also having a specific sour smell of leavened dough. Similarly, Lynch et al. (2009) reported a significant increase in the maximum dough volume as the salt level decreases from 1.2% to 0.0%. The study also reported the negative effect of the reduced salt amount on dough gas holding capacity. The authors mention that at salt concentration below 0.3 % (w/w) the gluten network is weak and the formed CO_2 escapes from the dough [38].

Effect of salt reduction on baked grissini's sensory scores

The sensory attributes of grissini samples in terms of crust surface, crust color, taste and flavor, shape, crumb texture and crunchiness were evaluated after 12 hours from preparation. The results of the organoleptic examination of grissini samples with different salt concentrations are presented in the table 3.

Table 3

The results of the sensory evaluation for grissini

	Control	$G_{50\%salt}$	$G_{25\%salt}$	$G_{0\%salt}$	KG	WG	SBG
Crust surface	5.00±0.00[a]	4.80±0.00[b]	4.30±0.00[c]	3.55±0.00[b]	3.90±0.00[b]	4.10±0.02[b]	4.80±0.02[b]
Crust color	5.00±0.00 [a]	4.90± 0.03[a]	4.50±0.00[b]	3.50±0.00[b]	4.20±0.01[a]	4.10±0.02[b]	5.00±0.00[a]
Taste and flavor	4.80±0.00[b]	4.80±0.01[b]	4.60±0.00[b]	3.50±0.00[b]	3.90±0.00[b]	4.00±0.02[c]	5.00±0.00[a]

Continuation Table 3

Shape	5.00±0.00[a]	5.00±0.02[a]	4.80±0.00[a]	3.90±0.00[a]	4.20±0.05[a]	4.50±0.00[a]	4.95±0.02[a]
Crumb texture	4.80± 0.00[b]	4.90± 0.00[a]	4.80±0.00[a]	3.90±0.00[a]	4.25±0.05[a]	4.15±0.00[b]	5.00±0.00[a]
Crunchiness	4.80±0.00[b]	4.60±0.00[c]	4.60±0.00[b]	4.00±0.00[a]	4.20±0.02[a]	4.35±0.01[a]	4.90±0.02[a]
Average score	4.90±0.00[ab]	4.83±0.03[b]	4.60 ±0.04[b]	3.72±0.02[b]	4.10±0.02[b]	4.20±0.02[b]	4.94±0.04[a]

Note. Results are expressed as mean ± standard deviation, insignificant ($p > 0.05$), in each line different letters [a-c] mean significant differences ($p < 0.001$). $G_{50\%salt}$ – grissini with 50% salt; $G_{25\%salt}$ – grissini with 25% salt; $G_{0\%salt}$ – grissini with no added salt; KG - kefir grissini (no added salt); WG - whey grissini (no added salt); SBG – sour borscht grissini (no added salt).

The trends in consumer liking scores for grissini samples, were that the grissini based on sour borscht with no added salt had the highest average score of 4.94 (figure 1). This is probably due to the salt that is naturally found in sour borsch (fact proved and by the determined salt amount in table 4). From the panelists'point of view, SBG had a pleasant taste and flavor, a little sour, the lack of salt was not perceived. In contrast, the liking scores for KG and WG were lower, being characterized by an unusual taste and flavor, also the crust surface and color was less uniform due to the milk proteins that are still contained in these fermentative products and probably to the length of dough fermentation period.

In the case of all water based samples, a direct relation was established between the salt amount and taste score: once one decreases, so does the other. We did not detect a statistically significant difference among the control and $G_{50\%salt}$ and $G_{25\%salt}$ samples, but did detect a major one for the $G_{0\%salt}$ sample. The average score of the $G_{0\%salt}$ sample was 3,72. The sample received low acceptability scores for all the analysed characteristics, mainly for crust surface, crust color and taste and flavor.

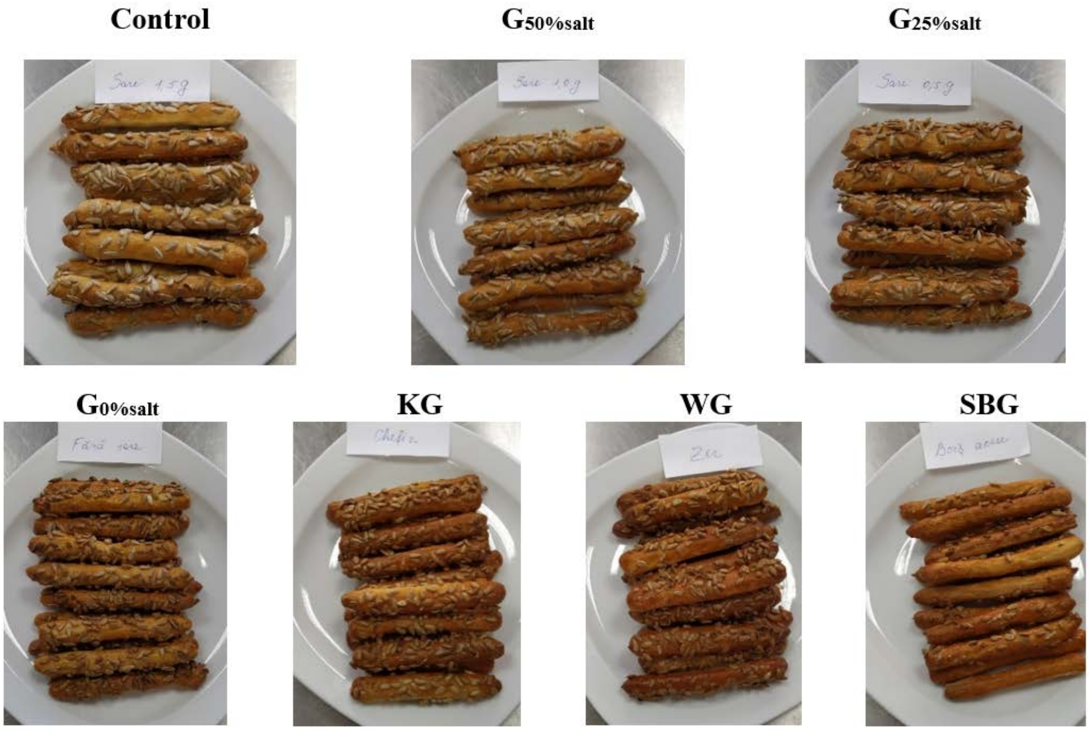

Figure 1. Sensory evaluation of grissini samples.

$G_{50\%salt}$ – grissini with 50% salt; $G_{25\%salt}$ – grissini with 25% salt; $G_{0\%salt}$ – grissini with no added salt; KG - kefir grissini (no added salt); WG - whey grissini (no added salt); SBG – sour borscht grissini (no added salt).

On one hand, in the view of some panelist, $G_{0\%salt}$ sample was dry and had no taste.

On the other hand, there were panelists that mentioned that the lack of salt is compensated by the taste of the sunflower seeds, confering to products a good and balanced taste. In their research Li et al. (2021) managed to reduce the salt content in bread by 20% (from 1.5 % to 1.2 % (w/w)) without impacting the consummer salt perception [37].

Also, in the study performed by Lynch et al., the panelists mentioned that salt free bread was yeasty, acidic and sour. The authors managed to reduce the salt content in bread from 1.2% to 0.3% (w/w) without significantly affecting the wheat dough rheological properties and bread-making performances [38].

Salt and moisture content of baked grissini

Determining the moisture content (W, %) in bakery and confectionery products is very important because it allows to establish the duration and storage conditions of the products, the low moisture content being associated with a longer shelf life [40]. According to the regulated physicochemical indicators established for grissini, the moisture content must not exceed 12.00% [43]. The moisture content as well as the salt content in grissini sticks are shown in table 4.

Table 4

Moisture and salt content in salt-free grissini

Sample	Moisture, %	Salt content NaCl, %
Control	11.80±0.21^{a}	1.63±0.10^{a}
$G_{50\%salt}$	11.66±0.08^{ab}	0.88±0.09^{b}
$G_{25\%salt}$	11.58±0.06^{b}	0.50±0.05^{c}
$G_{0\%salt}$	11.45±0.08^{c}	0.12±0.01^{e}
KG	11.73±0.11^{a}	0.70±0.04^{b}
WG	11.63±0.14^{ab}	0.38±0.01^{d}
SBG	11.57±0.07^{b}	0.53±0.02^{c}

Note. Results are expressed as mean ± standard deviation, insignificant ($p > 0.05$), in each line different letters ($^{a-e}$) mean significant differences ($p < 0.001$). $G_{50\%salt}$ – grissini with 50% salt; $G_{25\%salt}$ – grissini with 25% salt; $G_{0\%salt}$ – grissini with no added salt; KG - kefir grissini (no added salt); WG - whey grissini (no added salt); SBG – sour borscht grissini (no added salt).

Regarding moisture content, all the researched samples fall within the limits established by the technical regulations for grissini, ranging from 11.45 to 11.80 %, the highest value being obtained for the control sample. However, taking into account that the dough moisture content was the same in all cases, and that the differences among the moisture content values in grissini are not significant, these can be considered experiment errors.

The highest NaCl content (1.63 %) was found in the control sample. The lowest value of NaCl concentration was registered in the $G_{0\%salt}$ sample, in which no salt was added, with a value of 0.12 %. This is due to the fact that a small amount of salt is also found in the eggwash, as well as in the sunflower seeds. In fact, according to national and european legislative regulations this is the only sample that can be called "product with a reduced salt content" [41, 42].

In the samples prepared on the kefir, whey and sour borscht basis with no added salt, the NaCl content recorded values between 0.40 and 0.70%, which shows that the used fermentation products naturally contain salt. The highest NaCl content (0.70 %) was recorded for the KG sample, and the lowest (0.38 %) for the WG sample. The SBG sample, which was the most apreciated from sensory point of view, had a 0.53 % salt contet.

Effect of salt reduction on baked grissini's acidity

According to the national legislative regulations, the maximum allowable acidity for grissini-type bakery products made from premium wheat flour is 2.5 degrees [43], value marked with the horizontal red line in figure 2. The presented data indicate that the products prepared on water basis have the acidity that falls within the permissible limits. However, the salt content influenced the fermentation process, respectively in the control sample the acidity is 2.19 degrees, and in the salt free sample it reaches the value of 2.49 degrees. In the case of the KG, WG and SBG samples, the acidity recorded values above the admissible limit, ranging from 2.84 to 2.89 degrees, the highest value being obtained for WG.

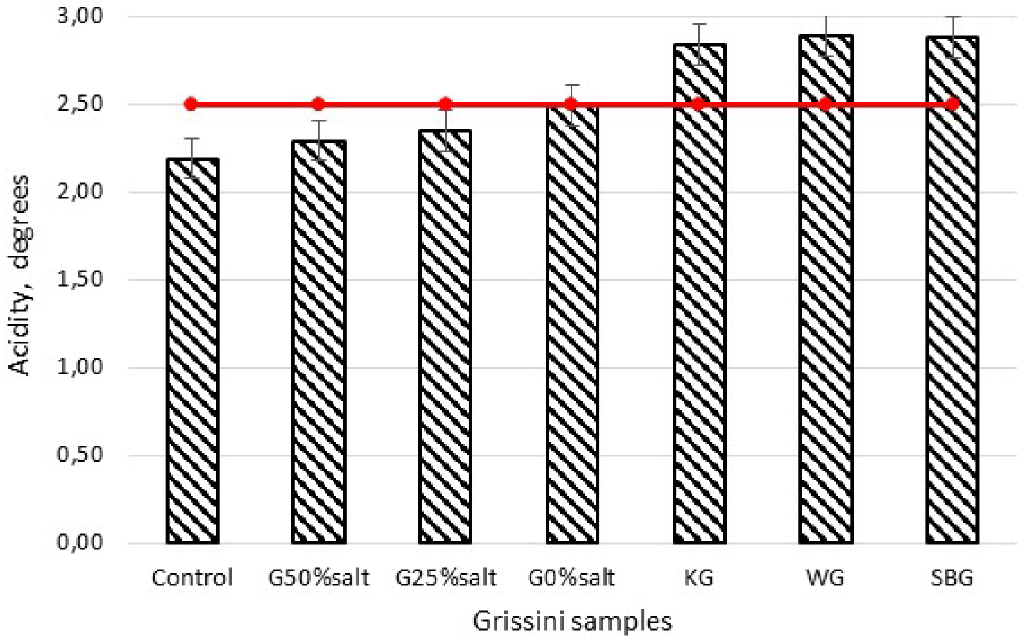

Figure 2. Effect of salt reduction on grissini's acidity.

$G_{50\%salt}$ – grissini with 50% salt; $G_{25\%salt}$ – grissini with 25% salt; $G_{0\%salt}$ – grissini with no added salt; KG - kefir grissini (no added salt); WG - whey grissini (no added salt); SBG – sour borscht grissini (no added salt).

On one hand, this can be explained by the natural presence of acids in whey, kefir or sour borscht [44]. On the other hand, the exceeding acidity may be caused by the fact that the fermentation period was the same for all samples, so a greater amount of acids was formed.

Thus, in the fermentation process the components of the kefir, whey and sour borscht would also have been involved. Probably shortening the fermentation period for this samples' dough would ensure acidity values of the baked products below the maximum admissible values, fact that will be taken into account in further research.

A greater acidity can influence to some extent the organoleptic qualities, namely the sour taste and the specific, less pleasant smell.

Contrastingly, numerous studies have shown that lactic acid produced by lactic acid bacteria found in whey, kefir or sour borscht has a positive effect on the inhibition of pathogenic microorganisms [45-47].

Effect of salt reduction on baked grissini's color parameters

Grissini with a lower salt content showed a less colored crust. Chromatic parameters, including total color difference and brown index of grissini samples are shown in table 5.

Table 5

Color parameters of grissini

Sample	L^*	a^*	b^*	ΔE	BI
Control	60.32±1.07[a]	5.82±0.11[a]	32.28±0.45[a]	-	39.68±1.14[a]
$G_{50\%salt}$	62.87±1.13[a]	5.48±0.08[a]	32.02±0.56[b]	2.59±0.02[a]	37.13±0.98[ab]
$G_{25\%salt}$	65.40±0.94[c]	4.94±0.17[c]	31.59±0.37[c]	5.20±0.08[b]	34.60±1.05[b]
$G_{0\%salt}$	68.54±0.74[d]	4.04±0.14[d]	30.85±0.78[e]	8.53±0.34[e]	31.46±1.65[d]
KG	63.75±1.26[ab]	4.72±0.07[b]	30.35±0.65[b]	4.09±0.02[a]	36.25±0.76[ab]
WG	63.88±1.08[c]	4.22±0.09[c]	28.38±1.02[d]	5.52±0.46[d]	36.12±1.68[c]
SBG	63.04±0.82[b]	4.43±0.21[d]	30.88±0.69[d]	3.36±0.58[c]	36.96±1.32[bc]

Note. $G_{50\%salt}$ – grissini with 50% salt; $G_{25\%salt}$ – grissini with 25% salt; $G_{0\%salt}$ – grissini with no added salt; KG - kefir grissini (no added salt); WG - whey grissini (no added salt); SBG – sour borscht grissini (no added salt). Results are expressed as average ± standard deviation, insignificant ($p > 0.05$), in each column different letters ([a-e]) mean significant differences ($p < 0.001$).

The color parameters (a^*, b^* and L^*) significantly changed as salt level decreased, due to a lower Maillard reaction intensity [48]. This can be explained by the fact that salt reduction increases yeast's activity, leading to a decrease of the amount of free reducing sugars involved in Maillard Reaction. Belz et al (2012) listed numerous positive effects of salt on bakery products, including bread color (more intense), delayed fermentation and the availability of a higher amount of sugars that may be involved in Maillard and caramelization reactions [49].

The data from table 5 clearly show that with salt reduction the L^* value significantly increased ($p > 0.05$) from control (60.32) to $G_{0\%salt}$ (68.54). In case of the samples with water substituents (KG, WG, SBG) same tendency was observed, but the L^* uptrends were not as sharp as in the case of water-based samples. On the contrary, the values of redness parameter (a^*) showed a slight decrease with the decrease of salt concentration, ranging within the limits 5.82 for the control and 4.04 for $G_{0\%salt}$. A similar decreasing trend was observed and for the b^* values, minimum value was recorded for the WG sample (28.38), while the maximum was in the case of control sample (32.28). The decrease of a^* and b^* values could be caused by the decrease of the Maillard reaction intensity between reducing sugars with the amino acids.

The values obtained for ΔE and BI, parameters that actually emphasize the effect of the salt content on the grissini's color changes to some extent are consistent with the data presented for the salt content. With the decrease of the salt content in the grissini's formulation, an increase of the total color difference is observed, which reaches values of 8.53 in case of total exclusion of salt. An opposite trend is observed in the case of BI evolution that reaches minimum values when salt was totally excluded.

Consumer test

The mean appreciation scores of reserched grisini samples depending on their salt content are reported in figure 3. The KG and WG samples were not subjected to this test because their assessment would have been influenced by the "unusual" taste and flavor mentioned by the panelists. From the ranking created by consumers, regarding the "favorite salty" taste, the SBG sample took the leading place. On the 2nd place was ranked the control sample, the accumulated score being without significant differences compared to SBG sample. Next to this samples were ranked $G_{50\%salt}$ ang $G_{25\%salt}$.

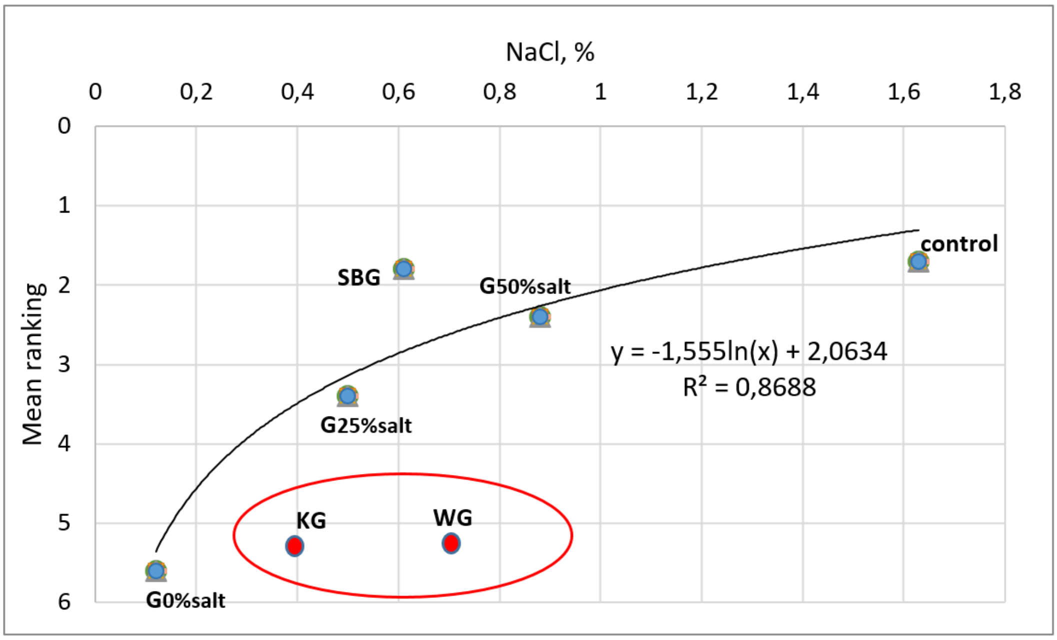

Figure 3. Mean ranking of grissini with different salt level.
$G_{50\%salt}$ – grissini with 50% salt; $G_{25\%salt}$ – grissini with 25% salt; $G_{0\%salt}$ – grissini with no added salt; KG - kefir grissini (no added salt); WG - whey grissini (no added salt); SBG – sour borscht grissini (no added salt).

Based on these, the SBG sample can be succesfully implemented in production, as long as the technology of production will allow to obtain grissini with acidity values within the admisible limits. Also, it can be concluded that salt intake can be reduced by up to 25 % without any changes in consumer preferences. Samples in which the salt was completely excluded obtained the lowest scores. As a result of processing the obtained scores, an exponential relationship was obtained that would allow the prediction of consumers' preferences regarding the acceptable salt level.

4. Conclusions

In this work, a simple method to reduce the salt level in grissini was reported. The results show that sour borscht, can be successfully used to replace the water in low or salt-free grissini in order to compensate the lack of salt and its impact on product quality. However, an aditional study is required in order to establish the optimal technological parameters for dough fermentation so as to maintain the acidity below 2.5 degrees.

The determination of the NaCl content in the grissini showed that for the samples based on kefir the salt content was similar to the sample with only 50% of salt amount. Regarding the same indicator, the whey based sample was closer to the grissini with 25% salt. Thus, to completely reduce the salt content of a complex product, the salt content of all ingredients must be taken into account.

Reducing the salt content negatively influenced the taste and flavor profile, moisture retention during baking and color parameters of grissini, leading to a lower sensorial score and a less intensely colored crust (weaker Maillrd reaction), but had a positive effect on dough raising capacity. Based on the values obtained as a result of the sensory evaluation, but also of the consumer test, the salt level can be reduced in the grissini formulation up to 25%.

Concerning the water substituents in the recipe, all the grissini samples had a higher titratable acidity than the admissible value, fact due to their richiness in acids. Additional studies are underway to evaluate the optimal fermentation period and optimal water replacement ratio with fermentation products to maintain this index within the admissible limits.

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