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SHORT COMMUNICATION

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BREADMAKING CHARACTERISTICS OF DOUGH WITH EXTRUDED CORN

Extrusion cooking is a thermal process often practiced in food, chemical and feed industry. Due to extrusion, nutritive value, texture, sensor characteristics and hygiene are improved. The influence of extruded corn grain and bread improver quantity on rheological and sensory characteristics of bread was investtigated in this paper. Experiment was planed according to factorial plan 3^2 with independent variables: quantity of extruded corn (10-30 % based in wheat flour, variation interval 10) and improver (0-0.4 % based on flour, variation interval 0.2). The influence of extruded corn on dough handling is illustrated by extensigraph data: in comparison to the dough without corn, area is decreasing 50 to 60 % and resistance to stretching 15 to 20 %. The addition of commercial bread improver, regardless the quantity of extruded corn is beneficial contributing to improved extensigraph data up to 30 %. By substituting wheat flour with 10 to 20 % of extruded corn along with proper quality of bread improver, bread quality is satisfying and stalling is significantly improved. In the production of so-called mixed corn bread (30 % of extruded corn) extrusion is contributing to retard stalling and prolonged shelf-life.

Key words: corn; extrusion; dough rheology; bread; quality.

Heat treatment is a process typically used to enhance nutritional, hygienic, physico-chemical and other characteristics of grain, that is, to improve nutritional value of some ingredients, upgrade sensory properties (for example, improves "mouthfeel" of treated corn), meet microbiological requirements of the product and inactivate heat-unstable anti-nutrients, if any. Heat treatments most commonly used for grain processing are extrusion, micronisation, hydro-thermal treatment, toasting and others [1-3].

Extrusion cooking is a versatile process that improves sensory and nutritional qualities of foods [4]. The cost-to-benefit ratio of extrusion technology gives producers, processors and consumers more choices as to increase the variety of ingredients used in cereal-based products [5].

According to the recommendations of nutritionists and health claims in prevention and curing of chronic nutrition-related diseases it was found that certain micronutrients are exerting beneficial effects in the body, innovations in food industry within the domain of bakery industry have been focused on the improvements of products nutritive value. Today a great variety of bread and bakery small goods attributed with altered nutritive value and decreased energy is present at the market [6]. Whole corn grain constituents are positively contributing to elevated fiber and vitamin E content as well as to better fatty acid pattern in wheat bread [7].

The aim of this research is to investigate the influence of extruded corn, as a function of supplemented quantity of extruded corn and improver, on dough rheology and bread quality and to prepare bread with corn attributed with good sensor characteristics and improved shelf-life.

EXPERIMENTAL

Commercial white flour (type 400), with 13.3 % moisture content, 0.41 % d.m. of ash and 26.5 % wet gluten, was used in the investigation. Commercially available bread improver MIL GH 2-2 was used in the formula at the level 0 to 0.4 %. Salt and yeast used in the bread formula were of food grade and were used at the level of 2 and 2.5 %, respectively, based on flour.

Mercantile corn with moisture content of 12.3 % was used for extrusion process. Corn was previously milled on hammer mill with Ø 3mm sieve. Milled corn

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was extruded in a extruder model M1000, "Metal-Matik", Beočin, with four heating segments (zones) in the extrusion process at 90 °C, and jet diameter of 8 mm.

Samples of non-treated corn (NC) and extruded corn (EC) are grinded in a hammer mill and sieved through a sieve with 200 μm openings and substituted white flour in the range 10–30 %. Basic chemical composition (moisture, crude proteins, crude fibre, crude fat and mineral substance contents) of corn and extruded corn was determined according to AOAC method [8].

Chemical analyses and dough rheology were done according standard procedures [9]. Baking test was done according to standard AACC procedure and bread was evaluated by three trained independent panellists [10].

RESULTS AND DISCUSSION

Characteristics of extruded cereals

Chemical characteristics presented in the Table 1 point that thermic extruded corn in comparison to non-treated, has lower crude fat and mineral substance content. Extrusion process has no influence on cellulose and content but evident changes occur in total sugar content. When compared to the non-treated corn, the total and reducing sugar content of the extruded corn are doubled.

Table 1. Chemical characteristics of non-treated and extruded corn

Quality indicators, % d.m.	Non-treated corn	Extruded corn
Protein content	8.9	9.7
Fibber content	4.0	4.0
Fat content	6.2	5.6
Mineral substance content	1.5	1.1
Starch content	74.1	72.8
Total sugar content	3.4	7.4
Reducing sugar content	2.4	4.9

Dough rgeology

Data presented in Table 2 point at significant changes in dough rheology caused by substituting wheat flour with 10 to 30 % of extruded corn. In comparison to wheat dough extensigraph area and resistance to stretching of dough with extruded corn are decreasing for 50 to 60 % and 15 to 20 %, respectively. Positive contribution of bread improver quantity on dough characteristics is evident. It is greater in the dough without corn but it is also present in the amount of 15 to 30 % in the doughs containing corn.

Quality of bread with extruded corn

Bread quality, expressed through bread yield, volume and crumb quality, is defined as a function of extruded corn (EC) and improver quantity. Based on the data from Table 2, it is evident that extruded corn and improver did not have a significant influence on

Table 2. Effect of extruded corn (EC) and improver on dough rheology

Sample	Extensigraph parameters			
	Area[a], cm^2	Resistance to stretching (Ej)	Extensibility, mm	Resistance/Extensibility
		Control sample		
0 % improver	81.7 ± 1.43	357.5 ± 10.6	140.5 ± 4.9	2.5
0.2 % improver	69.9 ± 15.1	560.0 ± 14.1	101.0 ± 4.2	5.5
0.4 % improver	67.1 ± 5.64	445.0 ± 7.1	114.5 ± 3.5	3.9
		10 % of extruded corn		
0 % improver	60.9 ± 1.03	355.0 ± 35.4	121.5 ± 7.8	2.9
0.2 % improver	67.5 ± 5.93	520.0 ± 28.3	115.0 ± 7.1	4.5
0.4 % improver	46.1 ± 0.25	385.0 ± 21.2	110.5 ± 4.9	3.5
		20 % of extruded corn		
0 % improver	30.1 ± 1.32	270.0 ± 42.4	103.0 ± 1.4	2.6
0.2 % improver	37.0 ± 1.41	390.0 ± 42.4	89.5 ± 6.4	4.4
0.4 % improver	40.1 ± 5.23	390.0 ± 14.1	91.5 ± 7.8	4.3
		30 % of extruded corn		
0 % improver	23.5 ± 1.10	295.0 ± 7.1	66.0 ± 5.7	4.5
0.2 % improver	20.9 ± 2.86	242.5 ± 3.5	74.0 ± 8.5	3.3
0.4 % improver	16.8 ± 2.42	215.0 ± 14.1	82.0 ± 2.8	2.6

[a]Average ± standard deviation

bread yield, but bread volume is decreasing 15 to 40 %, depending on the level of flour substitution. Positive influence of improver on bread volume regardless EC quantity is from 25 to 40 %.

Data for bread volume are statistically estimated and the calculation of parameters was carried out using program Statistica, version 4.5. The regression equation calculated based on the experimental results is:

$$z = b_0 + b_1x + b_2y + b_{11}x^2 + b_{12}xy + b_{22}y^2$$

where b_0, b_1, b_2, b_{11}, b_{12} and b_{22} are regression coefficients, x is quantity of extruded corn supplemented to flour, y is quantity of improver and z is dependent variable (bread volume).

Regression coefficients b_1 and b_2 point linear effect of non-dependent parameters x and y on dependent variable z, b_{11} and b_{22} a square effect and b_{12} a linear interaction between two non-dependent variables.

In order to faciliate the interpretation of statistical data, the results of regression analysis are presented by 3D diagram, Figure 1. It is evident that bread volume is significantly adversely affected by the quantity of implemented extruded corn and that is in accordance with earlier experience [7,11]. The addition of improver is diminishing the negative effect of extruded corn on non-dependent variable and the maximum positive effect is attained with the addition of bread improver at the level of 0.2 %, while 0.4 % of improver is contributing to volume decreasing from 15 to 20 % depending on the corn substituted level.

Bread crumb quality, expressed as a sum of scores for crumb grains and crumb elasticity 24 and 48 h after baking, point that extruded corn at the substitution level of 10 and 20 % in the dough formula did not significantly cause the crumb quality deterioration. As expected [7,11], the least scores for crumb quality are experienced with bread that had maximum quantity of extruded corn and the smallest quantity of improver, Table 3. Bread volume decrease and slight crumb quality deterioration of bread containing 30 % of extruded corn is due to dilution effect of wheat gluten [5,7]. The benefits of extrusion process, increased level of gelatinized starch and sugars are evident in bread 48 h after baking.

Scores for crumb quality 48 h after baking for bread with extruded corn decreased 15 to 45% in comparison to scores 24 h after baking but these decrease is up to 70% in white bread (control). Extruded corn positively contributed to retarded stalling and prolonged freshness of bread crumb. This technological process is a safe tool that is solving a well-known problem of rapid crumb deterioration of bakery products containing corn.

Bread improvers are beneficial in elevating the quality of bread with 10 and 20% extruded corn at the level close to the quality of white bread. By incressing corn substitution level to 30%, bread improvers are enabling to attain crumb quality attributes and shelf-life the same or better than white bread. Elevated quantities of whole corn grain constituents are increasing fibers, vitamins and nonsaturated fatty acids in daily bread positively contributing to human health without adverse effects on stalling.

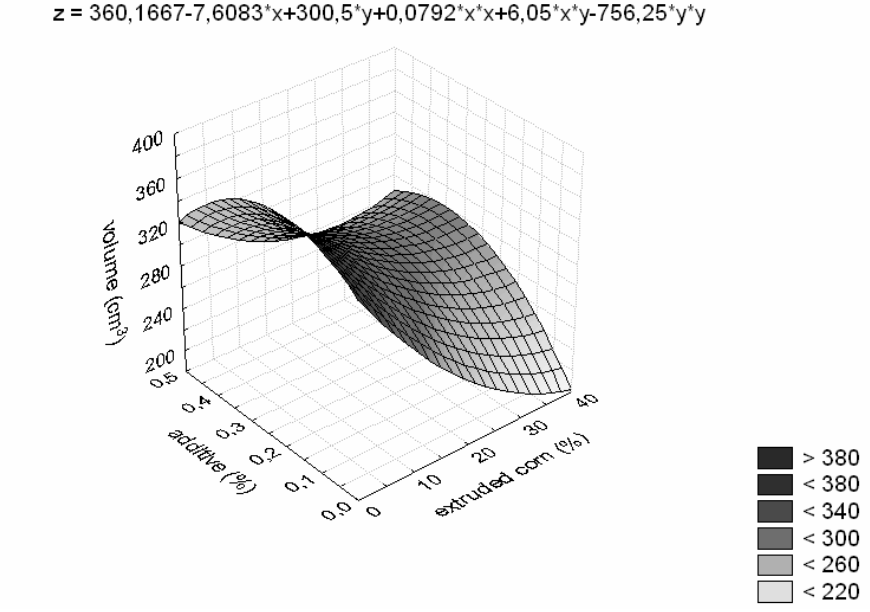

Figure 1. Effect of extruded corn and improver quantity on bread volume.

Table 3. Effect of extruded corn (EC) and improver on bread quality

Sample	Bread quality			
	Bread yield, g/100 g flour	Volume yield, cm^3/100 g flour	Crumb quality* (24 h)	Crumb quality* (48 h)
Control sample				
0 % improver	145.3	391.2	5.0	1.4
0.2 % improver	145.3	374.9	5.3	2.4
0.4 % improver	149.6	429.8	6.7	2.5
10 % of extruded corn				
0 % improver	146.2	336.4	4.6	1.4
0.2 % improver	143.9	400.9	5.5	3.2
0.4 % improver	143.8	299.8	5.6	3.2
20 % of extruded corn				
0 % improver	146.5	227.8	4.2	2.0
0.2 % improver	142.7	323.6	4.6	2.8
0.4 % improver	145.7	288.9	5.0	3.2
30 % of extruded corn				
0 % improver	144.7	214.5	2.1	1.6
0.2 % improver	137.7	274.5	3.0	2.5
0.4 % improver	143.1	304.3	4.2	2.8

*Bread crumb quality scores: 7.0 - the best, 0 - the worst

CONCLUSION

Based on the data of the influence of extruded corn on dough and bread quality it can be stated:

– Changes in stach due to extrusion contribute to elevated content of total and reducing sugars.

– Extruded corn is adversely affecting dough rheology on the whole. Supplemented quantity of extruded corn is decreasing extensigraph area and resistance to stretching 50 to 60 % and 15 to 20 %, respectively. Regardless the quantity of extruded corn in formula, bread improvers can diminish negative effects but still dough characteristics are not reaching the level of samples without corn.

– Extruded corn is significantly affecting bread volume and the decrease is between 15 and 40 %. The addition of bread improver is beneficial.

– Bread containing 10 or 20 % of extruded corn, on the whole, is scored as a very good and retarded stalling is beneficial.

– Extruded corn can be successfully used for making "mixed corn bread" (30 % of corn) because of its positive contribution to retarded stalling. Bread crumb quality of this bread is much better keeping freshness in comparison to white bread.

– The results of these investigation point at extrusion process as a convenient technological tool that can successfully replace long term thermic procedures of soaking or cooking that as pretreatment of corn were practised in bakeres.

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