UDC: 664.66+[633.34:664.762
original scientific paper

Acta Agriculturae Serbica, Vol. XI, 21 (2006) 29-36

Acta Agriculturae Serbica FACULTY OF AGRONOMY • ČAČAK •

Bread With Extruded Corn Products

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Abstract: The influence of extrusion temperature of corn meal (95, 110, 120, 130 and 140°C) and extruded corn grain (90, 100 and 110°C) on bread quality is investigated in this paper. White flour baker's grade was substituted with 5, to 30% of extruded corn products. Changes of dough rheology and flour baking characteristics are traced related to corn extrusion temperature and its share in the dough formula. Extruded corn products are atributed with a significant water absorption and water retention (95 to 300% related to the extrusion temperature) positively contributing to the yield of bread and retarding staling. Very good bread quality (crumb quality) is attained by substituting 5% white flour with of corn meal or by substituting 30% of white flour with extruded corn grain at 100°C.

Key words: corn, extrusion, bread, quality.

Introduction

Extrusion is a thermic process widely applied in many industries. In food and feed industry, either cereal food components or complete food are extruded. This thermic prosess is improving nutritive and phisico-chemical food characteristics as well as its hygiene thus positively contributing to better conversion of certain nutrients, improving its sensor characteristics and microbiology (Filipović et al, 2005a i b). Concerning cereals, during extrusion, carbohydrates, i.e. starch, are undergoing the most significant changes. Due to partial gelatinization, starch is becoming more available to enzyme degradation, so *in vivo* and *in vitro* digestibility is increased. Extrusion include following structural changes: loosing crystal structure, glycoside bonds breaking and formation of new interactions at molecular level (Gonzáleys et al., 2002). Concerning human food, it is worth emphasizing that a

Accknowlegment: This research is financially supported by the Ministry for science, technology and development AP Vojvodina. (Projct Nr.114-451-00568/2005-01).

share of native starch is transformed into resistant starch increasing total fiber content, a component that is of particular intererst in the diet of developed and industialised countries (Nelson, 2000).

This paper was focused on the relation between extrusion temperatures of extruded corn or corn meal and dough rheology and bread quality. The main aim was to enlarge the pallet of corn containing bakery products, presuming that extrusion in comparison to non-treated corn, will contribute to better sensory and nutritive characteristics of bread.

Material and Methods

This research was carried on following raw materials: (1) *corn meal* (CM) a waste product containing whole corn sead coat, germ and a part of endosperm, originated from corn mill »Tisa«- Mirotin from Vrbas – prior to extrusion this raw matrial was tempered to the moisture contetnt of 20% and subjected to extrusion at following temperatures: 95°C, 110°C, 120°C, 130°C and 140°C (in subsequent text denoted as ECM and adequate temperature) in extruder Model 11-1000 produced by »Metal-Matik« from Beočin; (2) *whole corn grain* (CG) was tempered to the moisture content of 18% and subjected to extrusion on the above mentioned extruder and following extrusion temperatuires were applied: 90°C, 100°C and 110°C (in subsequent text denoted as ECG and adequate temperature). After extrusion, cooled samples were grinded at a hammer mill produced by »Metal-Matik« from Beočin, sieved through the sieve with 1 mm openings. The influence of corn on dough and bread characteristics, white flour of commercial grade (moisture and ash content 13,0% and 0,46%, respectively, wet gluten 26,1% and falling number 458 s) was used.

Viscosity was tested according to standard amilogaph method and water retention and solubility in accordance with the procedure described by Stauffer (*1993*).

Bread was baked according to standard AACC metdhod and bread quality was evaluated sensory by test panel of three experienced person (Kaluđerski, Filipović, 1998; Filipović, 2005).

Results and Discusion

Characteristics of extruded corn products

Phisico-chemical characteristics of extruded corn products depend upon extrusion temperatures. For breadmaking, of particular interest are changes on starch that contribute to water absorption and retention, properties important during mixing, dough handling and baking. Extrusion temperature is significantly influencing amilogaph viscosity. Corn meal extruded at 95ºC is characterised by the highest peak viscosity of 960AU, but the lower peak of 540 AU is accompanied with the sample extruded at the highest temperature -140°C pointing that by extrusion at this temperature peak viscosity is only half of the value of non-treated corn sample, table 1. Peak viscosity decreased due to partial starch gelatinization caused by extrusion, so only non-gelatinized starch is binding water while corn suspension is heating

(Prodanović, 1992). Similar influence of temperatures on peak viscosity is observed if whole corn grain is extruded, but viscosity decreased at less extent, due to lower extrusion temperature table 1.

Table 1 The influence of extrusion temperature on viscosity and physical characteristics of extruded corn products

sample	Peak viscosityy [AU]	Water retention [%]	Solubility [%]
CM	1100	25	0,5
ECM 95°C	960	95	1,8
ECM 110°C	880	152	1,6
ECM 120°C	810	243	2,0
ECM 130°C	660	262	2,8
ECM 140°C	540	302	3,0
CG	1050	22	0,4
ECG 90°C	900	108	2,1
ECG 100°C	850	140	2,7
ECG 110°C	800	155	1,7

Legend

CM – corn meal
ECM95°C – extruded corn meal at 95°C
ECM110°C – extruded corn meal at 110°C
ECM 120°C – extruded corn meal at 120°C
ECM130°C – extruded corn meal at 130°C
ECM140°C – extruded corn meal at 140°C
CG – Non-treated corn grain
ECG90°C – extruded corn grain at 90°C
ECG100°C – extruded corn at 100°C
ECG110°C – extruded corn at 110°C

Increased temperatures and available water are intensifying swelling of starch and a part of soluble starch is becoming a constituent part of the solution. Due to absorption and hydration, amylose and amylopectin are being transformed to a gelatinised form. Above mentioned processes are more intensified in case starch grains are more damaged, or if higher temperatures are applied during thermic treatment. Damaged starch is absorbing water to greater extent during a shorter period and the share of soluble starch is also increased, table 1, fig.1

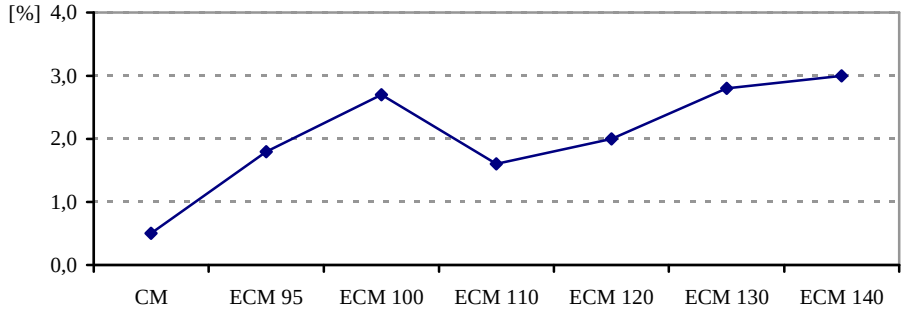

Fig. 1. Solubility of extruded corn meal

The ability of raw material to retain water in yeast dough formula is enabling incorporation of more water thus positively contributing to higher bread yield. Greater share of water should not adversely affect dough handling (Filipović, Šoronja Simović, 2004). By incorporating extruded corn products capable to bind 95 to 300% of water, beside increased bread yield, retard crumb stalling could be also expected. That way extruded corn is positively contributing to a prolonged bread shelf-life.

Rheology of the dough with extruded corn

By supplementing 10 to 30% of white flour with either non-treated or extruded corn, significant changes in farinofraph and extensigraph data could be detected. Negative effects on dough rheology are closely related to the quantity of supplemented flour.

In case, white flour is supplemented with non-treated corn, water absorption is decreasing approximately 10% pointing that native corn flour is binding less water than wheat flour. As a consequence of thermal treatment during extrusion, the share of damaged starch is increased and is accompanied with increased water absorption - up to 5%. Dough consistency, presented in table 2, as 15 min drop, is increasing in both cases, either nontreated or extruded corn is supplemented. Maximum deviation amounting 75% is detected in case 30% of white flour is supplemented with 30% of extruded corn. This negative effect is also proved by decreasing farinograph class and extenigraph area from B2 to C1 and 1 to 65%, respectively, table 2. The extenigraph data, ratio resistance to stretching to extensibility ranges between 3,1 and 5,2 reaching unfavourable values recommended for bread dough (optimum 1,5-2,5) but at the same time point at the ability of extruded corn to retain water during dough handling.

Based on dough rheology good corn bread could be expected in case 30% of white flour is supplemented with extruded corn.

Table 2.The influence of corn quantity on dough rheology

Rheology data	Control	Nontreated corn			Extruded corn		
		10%	20%	30%	10%	20%	30%
		Farinograph data					
Absorption [%]	56,6	51,4	51,0	49,4	54,0	58,2	61,1
Dough stability[min]	5,0	4,0	5,0	5,0	4,0	5,5	5,0
15 min drop time[BU]	90	85	105	100	95	135	155
Number of quality/class	53,2/B2	57,3/B1	56,4/B1	59,6/B1	57,9/B1	50,4/B2	42,4/C1
		Ekstensigraph data					
Area [cm^2]	98,9	67,2	37,9	34,8	97,8	62,8	47,3
Resistance to extension [EU]	343	585	465	413	468	375	310
Extension [mm]	155	120	104	80	127	117	100
Ratio resistance to extension	1,1	4,9	4,5	5,2	3,7	3,2	3,1

Quality of bread with extruded corn products

The influence of corn extrusion temperatures on bread crumb quality is tested in case 5% and 30% of extruded corn meal and extruded corn grain, respectively are supplemented in the dough formula. Bread quality presented in tables 3 and 4 is evaluated through following characteristics: bread volume and number of crumb quality that represent the sum of numerical values for crumb elasticity and crumb grain structure (Kaluđerski, Filipović, 1998).

Depending upon corn extrusion temperatures bread volume is decreasing from 10 to 25%, table 3. crumb quality is also decreasing, i.e. crumb elasticity and grain structure are evaluated by lower grades. As a consequence of chemical composition and small share, the best bread crumb quality is experienced if extruded corn meal is incorporated into the formula -5,8. Corn meal is characterised by a greater share of so called non gluten components (germ lipids, nondigestible carbohydrates originated from seed coat). Higher extrusion temperatures are not favourable concerning bread quality on the whole, particularly crumb is decreased from 10 to 50%, table 3

Table 3. The influence of 5% supplementation of corn meal on bread quality

sample	**Yield of bread [g/100 g flour]**	**volume [ml]**	**Bread crumb quality***	
			[24h]	**[48h]**
Control, white flour	145,9	355	6,5	4,5
CM	146,6	320	5,8	3,9
ECM 95°C	147,7	305	5,0	4,0
ECM 110°C	147,8	280	4,1	3,6
ECM 120°C	147,1	260	4,0	3,2
ECM 130°C	148,0	255	3,9	3,0
ECM 140°C	148,2	245	3,6	2,8

*bread crumb quality: min 0,0 max 7,0

Data presented in table 4 point that supplemented extruded corn deteriorate bread volume from 10 to 30% but significantly increase bread yield.

Table 4. The influence of 30% of extruded corn grain on bread quality

Sample	**Yield of bread [g/100flour]**	**Volume [ml]**	**Bread crumb quality***	
			[24h]	**[48h]**
Control / white flour	149,1	355	6,5	4,5
CG	143,3	305	3,7	2,0
ECG 90°C	149,1	270	5,4	4,6
ECG 100°C	151,7	260	5,8	4,7
ECG 110°C	157,2	250	5,0	4,2

*The same as in table 3

Corn extrusion is diminishing adverse effects of non-treated corn on crumb grain structure, thus crumb quality is evaluated by better grades, even up to 50% in comparison with the bread containing the same quantity of non-treated corn, table 4. Crumb quality of bread with 30% of extruded corn is very close to the quality of white bread (control). Bread of the best quality (crumb quality evaluated as 5.8) is attained if corn extruded at 100°C is incorporated into the dough formula, fig 2. Particularly, it is worth emphasizing the benifit influence of extrusion on bread staling, experienced by high scores for bread crumb quality 48h after baking.

Fig. 2. The influence of corn extrusion temperature on bread quality (30% of corn)

Comparing data presented in tables 3 and 4, it is evident that extrusion of whole corn grain enables incorporation of much higher shares of such corn with minimum crumb quality deterioration, contrary to extruded corn meal. By incorporating extruded corn meal in dough formula, fibers and poly unsaturated fatty acids enrich bread, but higher shares significantly deteriorate bread quality and therefore for so called corn "wheat mixed bread" extruded whole corn is recommended.

The application of extruded corn in bread making is justified because thermic treatment contributes to increased bread yield and shelf-life. Extruded corn meal is beneficial as a flour supplement without particular declaration (maximum 5%) but for corn wheat mixed bread (flour supplementation minimum 30%) corn grain extruded at temperatures round 100°C is highly recommended.

Conclusion

Based on data related to corn extrusion temperatures and bread quality it can be stated:

- Physical characteristics of corn like water binding and retention depend on extrusion temperatures;
- In the aim to make a product attributed with high water binding and water retaining capacity in bread dough for every type of corn product optimum extrusion regime should be determined;

- Corn meal extrusion is a process that enables better valorization of waste products;

- Extruded corn meal could be used as a flour replacement in the quantity up to 5%;

- The use of extruded corn meal is highly recommended because it contributes to flour water absorption and enrich bread with fiber, unsaturated fatty acids and germ vitamins;

- Corn wheat mixed bread with extruded corn is attributed with superior quality, and prolong shelf-life in comparison with nontreated corn.

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HLEB SA EKSTRUDIRANIM KUKURUZNIM PROIZVODIMA

- originalni naučni rad -

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Rezime

U radu je ispitivan uticaj temperature ekstrudiranog stočnog kukuruznog brašna (95, 120, 130 i 150^{o}C) i ekstrudiranog celog zrna kukuruza (90, 100 i 110^{o}C) na parametre kvaliteta hleba. Brašno T-500 zamenjeno je sa 5, 10, 20 odnosno 30% ekstrudiranih proizvoda i praćene su promene reoloških i pecivnih svojstava brašna zavisno od temperature ekstrudiranja kukuruznih proizvoda i njihovog udela u testu. Ekstrudirani proizvodi od kukuruza imaju izraženu sposobnost vezivanja i zadržavanja vode (od 95 do 300% zavisno od temperature ekstrudiranja), što povećava prinos testa i prinos hleba, usporava starenje i produžava upotrebnu vrednost proizvoda. Veoma dobar kvalitet hleba (vrednosni broj sredine 5,8) postiže se zamenom 5% ekstrudiranog stočnog brašna kao i dodatkom 30% termički tretiranog kukuruza na 100^{o}C.