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## **STARCH EXTRUDATES AS A SOURCE OF LOW MOLECULAR DEXTRINS SLOWING DOWN BREAD STALING**

### **A b s t r a c t**

It has been observed that low mass dextrins can prevent bread staling by modifying gluten-starch interaction. Extruded starch is significantly decomposed. Thus it could be used for an increase of level of low molecular mass dextrins in bread. Studies were carried out on effect of starch extrudates supplement on the quality and staling of the baked pup loaves.

### **Introduction**

Bread staling includes all changes that take place after baking, unless they are caused by microorganisms. This includes organoleptic changes in taste, smell and texture (crumb hardens and loses its elasticity, crust softens and becomes chewy) but also structural and molecular changes, which include loss of water binding capacity of crumb, water solubility, enzymatic susceptibility of starch, microscopic changes in crumb and increase of starch crystallinity [Kim, D'Appolonia, 1977, D'Appolonia, Morad 1981].

Up-to date many different models of staling have been suggested. They are all based on a fact that bread dough consists of three main components: starch, water and proteins in proportion: 6:5:1. The models try to explain their role in establishing bread microstructure and staling. Martin and Hoseney [1991] in their model focused on the interaction between swollen starch granules and continuous gluten phase. They observed that weak hydrogen bonds make the structure elastic, but in time the bonds become stronger and more numerous, which is the cause of textural changes. This model is consistent with experiments which show that crumb hardening is higher when starch granules are more swollen. It also explains why only dextrins with long enough

DP (12-15) could stabilize crumb structure thus increasing staling. Dextrins with DP less than 9 are too short for cross linking so they have an opposite effect. Many other models explain staling as an effect of starch recrystallization [Kim, D'Appolonia, 1977, Neukom, Rutz, 1981, Krog et al., 1989]. It seems that staling is a complex process, which depends on the gelatinization and swelling of starch granules, as well as on retrogradation, changes in moisture content and interactions between the components of crumb. We can't neglect any of these factors [Gambuś 1997].

Preparations of bacterial alpha-amylases have been shown to reduce the process of crumb hardening by supplying low molecular weight dextrins [Martin, Hosney 1991, Lin, Lineback, 1990]. But such enzymatic preparation can also cause some uncontrolled changes in stored bread. An interesting alternative for such treatment is the modification of dough by decomposed starch supplement [Gambuś 1997]. To avoid chemical contamination, for our experiments we have chosen extrusion cooking- clean and rapid method of starch degradation.

## Materials and methods

A single-screw extruder (Brabender 20DN) was used to extrude the starches: wheat, corn, potato. The starch moisture contents were adjusted to 16% or 24% (dry basis). The temperatures in 3 barrel sections of extruder were: 80, 120 and 150, the screw speed was maintained at 210 rpm.

For the SEC analysis we used four columns with Sephacryl gel: S-200 (1.6 x 50 cm), S-200 (1.6 x 82 cm), S-500 (1.6 x 90 cm) and S-1000 (1.6 x 88 cm). 2 cm<sup>3</sup> of DMSO solution containing 0.025 g of starch extrudates were eluted with aqueous 0.005 M NaOH. RI Detector was used for on-line detection.

To check if the dextrins present in the extrudates may have similar effect as those produced by enzymes, the extrudates were milled and used for baking of 40 g pup loaves. Laboratory bread baking was performed using straight method. The dough contained 80 g of starch, 20 g of gluten, 8 g of sugar, 3 g of salt, 1.5 g of yeast and 70 cm<sup>3</sup> of water. In supplemented pup-loaves 3% of starch was replaced with extrudates. On the day of baking: bread volume, organoleptic scores, and penetration (hardness) using PNR - 10 penetrometer were estimated.

In addition, the process of staling during 3 days of storage in plastic bags at 23-24°C at relative humidity 64% were assessed. Following parameters were considered: changes in crumb humidity, dry substances of crust and crumb penetration.

On each day water extract of crumb was prepared by modified method of Neukom and Rutz [1981]. Blue value was measured as an indicator of free amylose present in bread crumb [Morrison, Laignelet 1983].

SEC chromatography was applied to the water extracts of bread crumb. Total carbohydrate determination by anthron (540 nm) in 5 cm<sup>3</sup> fractions was done to measure low mass dextrans content.

## Results and discussion

Due to extrusion molecular-level processes take place. Starch melts or gelatinize, depending on moisture content [Qu, Wang, 1994]. Starch granules reduce their size [Zheng et al., 1995] and change their shape. Some glycosidic bonds within glucans break [Davidson et al., 1984]. The most important factors which affect the properties of extruded starch are barrel temperature, mechanical shear and moisture content in raw material [Owusu-Ansah et al., 1983, Diosady et al. 1985, Cai et al., 1995]. Generally, it's hard to predict which of these factors will be decisive in each situation [Cai, Diosady, 1993].

To establish at which moisture content level, at the same barrel temperature profile, starch was more decomposed, we have compared SEC profiles of the extruded products. The results (Fig. 1) were consistent with previously reported by other authors [Yamada et al., 1990, Chinnaswamy, Hanna, 1990, Davidson et al., 1984]. Starches extruded at lower moisture content contained glucans with lower DP. Thus they were chosen to be added to bread dough.

Our previous SEC experiments show that the extent of degradation during extrusion is significant and comparable for different botanical sources of starch [Ziobro R.

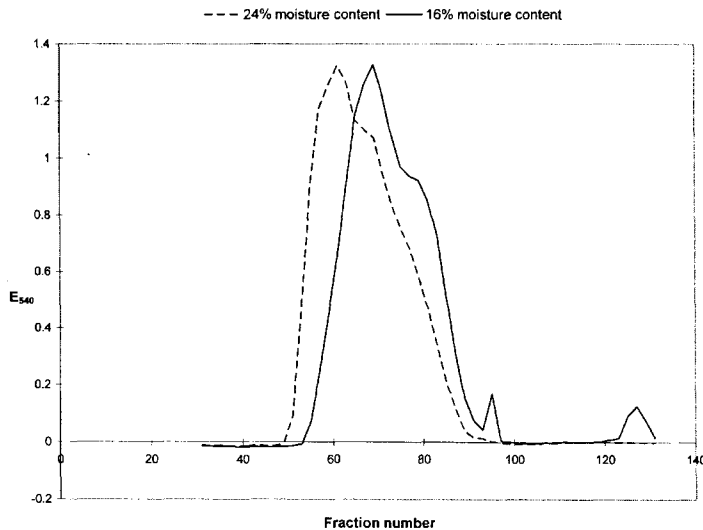


Fig. 1. SEC profile of wheat starch extruded at different moisture content.

et al., 1998]. Decomposed starch could be a good source of low molecular mass dextrans in bread, even if it wouldn't be much degraded. The processes (mainly enzymatic) that take place in bread during its preparation and baking cause some further degradation, and even after processing of a standard dough, where almost all starch glucans are intact, we could observe some oligosaccharides in water extract of crumb (Fig. 2).

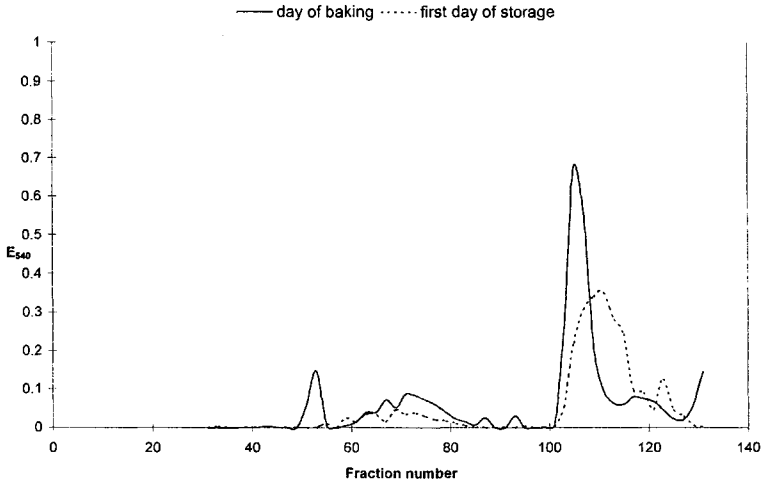


Fig. 2. SEC profiles of standard bread water extract.

Table 1 contains the data obtained on the day of baking and during storage of breads baked with supplement of extrudates. The volume of pup loaves was not affected by the addition of extruded starch. Organoleptic scores of the supplemented pup loaves were good, in two cases better than of one without extrudate. Crumb humidity of supplemented pup loaves was low in comparison with standard. Higher level of dry substance of crust suggests, that the extruded starches were converted into sugars, which produced more caramel.

The addition of extrudates reduced the hardening process as observed by penetration changes during storage period (Tab. 1). Changes in blue value, corresponding to soluble amylose content, were comparable for all breads. Therefore we think that in this case retrogradation was not responsible for the observed differences in penetration changes. Thus in our SEC experiments we concentrated on the range of low molecular masses. The results indicate that on the day of baking all pup loaves with the supplement of extrudates contained more dextrans and that these dextrans were shorter than in the standard pup loaf (Fig. 3).

Table 1

Quality assessment of model breads

Bread type	Volume	Organoleptic assessment		Day	Crumb humidity	Dry substance of crust	Penetration	Blue value
		Total points	Quality class		[%]	[%]		
Standard bread	102.5	33	II	0	40.90	70.13	9.27	0.11
				1	40.60	72.25	5.10	0.04
				2	35.45	72.25	3.30	0.02
				3	34.20	70.85	2.69	0.02
Bread supplemented with corn starch extrudate	102.5	37	I	0	37.75	84.37	9.99	0.12
				1	33.00	75.30	4.36	0.04
				2	32.45	73.00	4.19	0.03
				3	32.20	70.85	3.45	0.04
Bread supplemented with wheat starch extrudate	109.2	38	I	0	37.43	82.09	12.40	0.14
				1	35.46	73.45	6.50	0.05
				2	33.25	72.67	4.36	0.03
				3	32.60	71.94	4.12	0.03
Bread supplemented with potato starch extrudate	118.5	31	II	0	40.04	81.54	12.30	0.12
				1	36.68	74.07	6.00	0.05
				2	32.31	73.15	5.70	0.05
				3	30.78	72.36	5.20	0.04

0 - day of baking; 1- first day after baking; 2- second day after baking; 3- third day after baking.

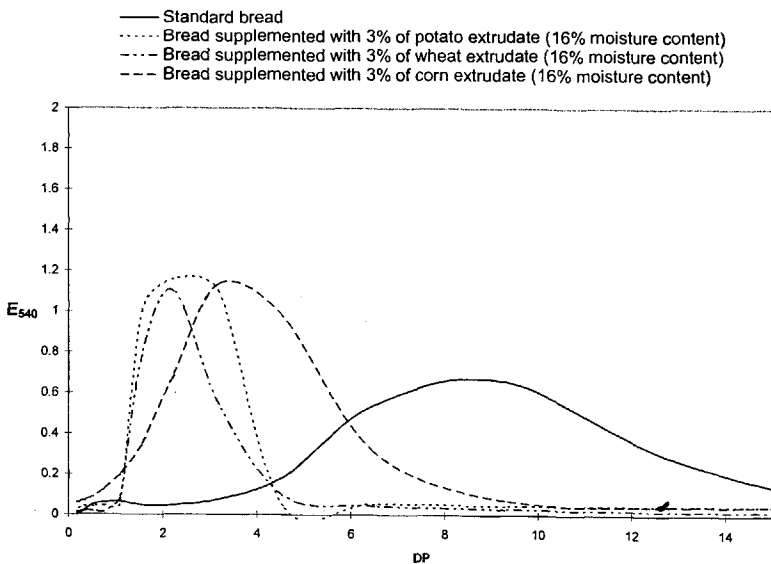


Fig. 3. Low molecular mass dextrans present in the water extracts of crumb prepared from pup loaves.

After storage the amount of dextrans with higher DP was reduced while the quantity of dextrans with lower DP was still the same or even greater. It is probably the result of interactions between dextrans with  $DP > 9$  with continuous gluten phase, which could have an impact on crumb hardening (Fig. 4a,b,c,d).

Pup loaf supplemented with corn extrudate (Tab. 1) was characterized by parameters similar to the standard one. It could be explained by the presence of dextrans larger than in other pup loaves (with potato and wheat extrudates) on the day of baking (Fig. 3).

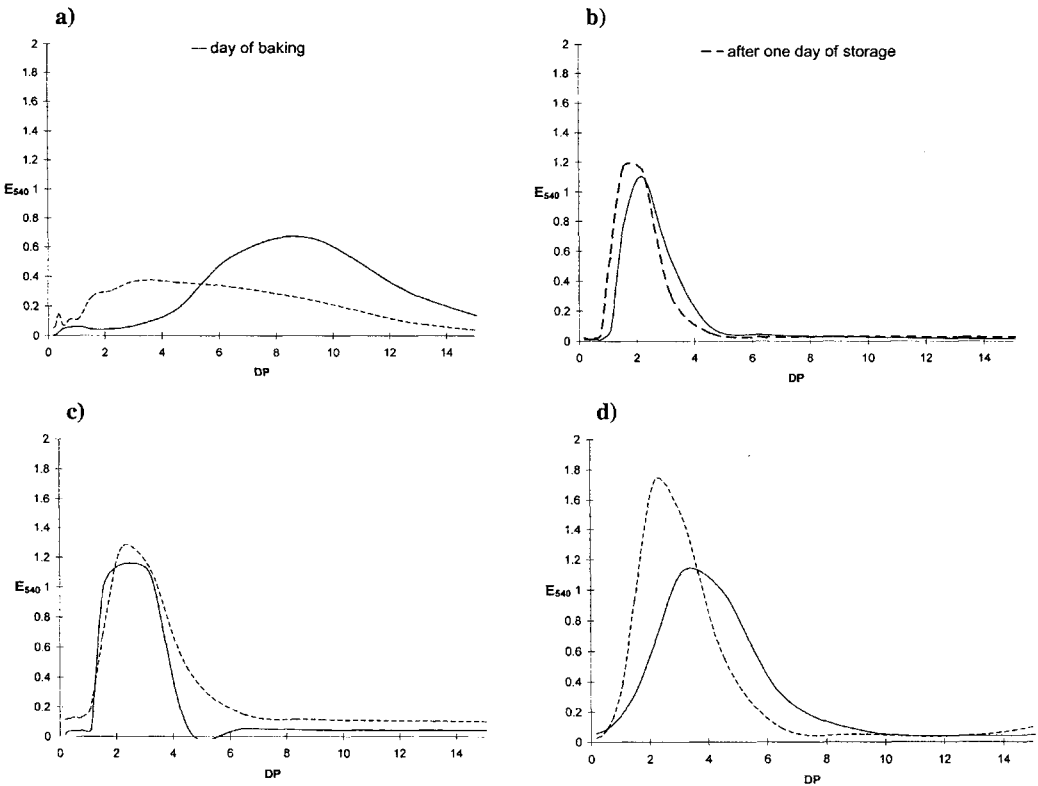


Fig. 4. Changes in fraction of low molecular mass dextrans present in the water extracts of crumb prepared from standard (a) and supplemented with corn (b), wheat (c) and potato starch extrudates (d) pup loaves.

The results show that bread staling corresponds to low mass dextrans content which could be acquired by addition not only of the enzymes but also starch degradation products such as extrudates.

## Conclusions

Starch extruded at lower moisture content was more decomposed.

Addition of wheat, potato or corn starch extrudates doesn't affect or even improves organoleptic properties of model bread so they can be used as its component.

All pup loaves with supplement of extrudates were characterized by softer and more elastic crumb on the 3 day after baking than standard.

The reduction of crumb hardening seems to be less affected by changes in retrogradation process and more influenced by low mass dextrins presence.

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## EKSTUDATY SKROBIOWE JAKO ŹRÓDŁO NISKOCZĄSTECZKOWYCH DEKSTRYN SPOWALNIAJĄCYCH STARZENIE SIĘ CHLEBA

### Streszczenie

Zaobserwowano, że niskocząsteczkowe dekstryny mogą zapobiegać starzeniu się pieczywa wpływając na interakcje pomiędzy glutenem i skrobią. Skrobia ekstrudowana jest w znacznym stopniu rozłożona, może więc być ona użyta do podniesienia zawartości niskocząsteczkowych dekstryn w chlebie. Dlatego w pracy przebadano wpływ 3% dodatku ekstrudatów skrobi pszennej, kukurydzianej i ziemniaczanej na jakość i starzenie się modelowych chlebków. Ekstrudaty skrobiowe sporządzano w jednoślankowym ekstruderze laboratoryjnym Brabender 20 DN. Stwierdzono, że udział skrobi ekstrudowanych w cieście modelowych chlebków spowodował poprawę ich oceny organoleptycznej oraz zahamował twardnienie miększa, co na podstawie analizy chromatograficznej (GPC) ekstraktu z miększa przypisano roli niskocząsteczkowych dekstryn pochodzących z ekstrudatów. ❧