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STARCH FROM IMMATURE CEREAL KERNELS AS AN IMPROVER OF BREAD

Abstract

The big starch grains of type A >10 μm in diameter are synthesised in cereal kernel until it reaches the early-waxy phase of maturity. In matured kernels 80% of total starch grains make up small grains of type B. It is known from earlier research that for creating the bread crumb structure big starch grains are needed because they swell and react with denatured gluten.

To improve the above mentioned proportions 5 and 10% of wheat, rye and barley starches were added to the baking of wheat breads from flour type 550. The starches were separated from kernels harvested in early and late-waxy phases. All breads were baked by direct method according to the same recipe. The volume of baked breads was measured, the sensory evaluation done and the texture profile of bread crumb was performed by TA-XT2 analyser. During three day storage hardness, springiness, cohesivness, gumminess, chewiness and resillence of bread crumb were estimated.

Starch additives did not affect the organoleptic value and the largest volume displayed breads with 3% starch additive from kernels in early-waxy phase of maturity irrespective of cereal species.

The origin and amount of added starch did not influence the texture parameters of bread with the exception of crumb hardness. All breads with starch additives were characterized by lower crumb hardness on the day baking and during three day storage in comparison with the standard bread. The most advantageous was an addition of 3 % of wheat and rye starches originating from kernels reaped in early-waxy phase of maturity. High resistance of such starch grains to swelling and pasting may have been responsible for that result (confirmed by DSC examination). Similar results can be obtained, for starch from mature kernels, only with the usage of certain inhibiting starch swelling substances in dough making. Usage of starches from wheat and rye kernels reaped in early-waxy phase of maturity eliminates addition of starch swelling inhibitors. The starch originating from grains of the early-waxy phase of maturity can be used as natural bread improver.

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Introduction

It was already stated a long time ago that the differences in physico-chemical properties of starch of various sorts of flour have an influence on their baking properties [5, 11, 12]. Since starch granules take part in the formation of dough structure, because they arrange themselves with long axes towards the mixing direction and form a large surface, on which glutenous proteins can be absorbed [23, 24].

Smaller starch granules have a relatively bigger surface of the contact with the gluten, however, during a process of baking some interactions between denatured gluten and big swollen granules have an impact on crumb structure . It has been proven by Pomeranz and his co-workers [23] in their work using a scanning electron microscope (SEM).

Soulaka and Morrison [24] suggested that the optimal number of small granules of type B (less than 10 µm in diameter) of starch contained in the flour should be not more than 35%, because over the limit the volume of bread decreases.

However, in their works Lelievre and his co-workers [16] proved that the optimal granulation of starch depends on the amount of protein in the flour. According to these authors, the less amount of protein is contained in the flour, there should be more small granules of starch in order to get the best quality of crumb.

In the starch contained in mature kernels of cereal small granules of type B form 80% of the total number of starch granules [10]. However, till 30 days after flowering, that is in the early waxy phase of kernel maturity, almost only large starch granules of type A (more than 10 µm in diameter) are being synthesized. Therefore, in order to improve starch granulation an additive of starch isolated from immature kernels to bread dough seemed to be justified.

The aim of the conducted experiment was to check whether starch isolated from the cereal kernels harvested from the field in the early and late waxy phases of kernel maturity can be used as an improver of bread.

Material and research methods

The research material was commerial wheat flour of type 550 and wheat breads, in which 3 and 5% of the mass of the flour was replaced with wheat, rye and barley starches isolated from immature kernels harvested from the field both in the early and late waxy phases of kernel maturity.

The technological value of the wheat flour of type 550 was evaluated taking the following into consideration:

- a number of sedimentations with SDS (dodecylo-sodium sulphate (VI)) by the micro method [2],

- a falling number (LO) by Hagberg-Perten's method in the apparatus *Falling Number – 1800* (Norm ICC- Standard 107) [13],
- an amount of gluten in the apparatus *Glutomatic 2200* (Norm ICC-Standard No 137) [13] and a gluten index in a special centrifugal machine according to the instruction of the Parten Company,
- physical properties of dough in a farinograph and resistograph of the Brabender Company and according to the norm ICC – Standard no 115 [13].

A laboratory baking of the breads of dough consistency 350 j.B. was conducted using a direct method [6]. After one and a half hour cooling the breads were weighted and a baking loss and bread making performance were calculated [14]. The volume of the obtained bread was measured in a loose material using seeds of rape. The sensory evaluation of the breads was performed on the day of baking according to PN-89/A-74108 [22]. The quality of the bread was determined according to the number of the collected points.

In order to study the process of staling the breads were being stored in foil bags at the temperature of 20–24°C. Starting from the day of baking on, for the whole period of storing, that is four days, we marked:

- moisture of the crumb by the drying method according to PN-89/A-74108 [22],
- texture profile of the crumb using a texture analyzer TA XT2 with a programme XTR-1. The bread was sliced in halves and from each half one 3 cm thick slice was cut off. In both slices a texture profile was marked measuring the following parameters: hardness, springiness, cohesivness, gumminess, chewiness and resillence.

Results and discussion

The wheat flour of type 550 used for baking the breads was characterized by good baking quality (Table 1). The opinion is supported by a favourable falling number, big water absorption, a long period of dough consistency, as well as a high content of gluten of good quality [2].

The wheat bread baked from this flour was treated as a standard. The influence of starch additives on the quality of the obtained breads was presented in Table 2. As one can conclude from the data contained in the table, starch additives did not worsen the organoleptic evaluation. The breads with 3% of starch isolated from the kernel harvested in the early waxy phase of maturity were characterised by the biggest volume, even bigger than the standard bread, regardless of species of cereal. The bread of bigger volume had a worse performance, because its mass was the lowest what proved that the loss of water in this type of bread was the largest during baking. However, it had no influence on moisture of the crumb, which in all the breads was similar, but it increased their baking loss.

Table 1

Evaluation of technological value of wheat flour type 550.

Kind of indicator	Flour type 550
Sedimentation number (cm^3)	28
Falling number (s)	286
Water absorption (%)	56,0
Time of dough development (min)	2,1
Time of dough stability (min)	3,8
Dough softening (B.U.)	100
Quality number	47
Wet gluten content (%)	27,2
Gluten index (%)	79,0

No increase in bread volume was noticed along with the addition of 5% of the starch isolated from the kernel harvested in the early waxy phase of maturity, because probably a certain optimum of the size of starch granules in flour was disturbed. The optimal starch granulation in flour depends on the content of protein in it [16]. It seems that with the presence of 27% of gluten, as was marked in the used flour, a 3% addition of "immature" starch, which maintained a given number of big granules, was the most favourable for bread volume.

No increase in bread volume was observed while adding the starch isolated from the more mature kernel harvested in the late waxy phase of maturity to dough, because such starch already contains a certain number of small starch granules of type B (Table 2).

Analyzing the changes of moisture of the crumb in the tested breads (Table 3-5) one can come to the conclusion that the loss of water from the crumb during the period of storing was not big, both in the standard breads and those ones with the starch additives. The results confirm the well-known theory that bread does not always need to lose water while staling, because an old and hard crumb often contains the same amount of water as the fresh one [1, 5].

Both the origin and the size of the applied additives had no visible impact on the parametres of crumb texture with the exception of its hardness (Tables 3-5). All the breads with the starch additives were characterized by a lower hardness of crumb in comparison to the standard bread, both on the day of baking and during the period of storage. However, for the sake of this characteristic a 3% additive of wheat and rye starch, which were harvested in the early waxy phase of maturity, appeared to be the most favourable (Fig. 1, 2).

Table 2

Selected quality parameters of wheat breads supplemented with starch isolated from immature wheat, rye and barley.

Kind of bread	Weight of cold bread (g)	Total volume of bread (cm^3)	Bread volume from 100g flour (cm^3)	Yield of baking (%)	Total baking loss (%)	Moisture of crumb (%)	Sensoric evaluation	
							Scores	Grade
Wheat flour 100% standard	223,5	7 63	491	143,9	10,6	43,2	40	I
Early-waxy phase of maturity								
Standard + 3% wheat starch	222	**775**	**499**	143,0	11,2	43,7	40	I
Standard + 5% wheat starch	226	705	454	145,5	9,6	42,6	40	I
Standard + 3% rye starch	226	**780**	**502**	145,5	9,6	43,6	40	I
Standard + 5% rye starch	221	725	467	142,2	11,7	43,4	40	I
Standard+ 3% barley starch	222	**780**	**502**	143,0	11,2	43,1	40	I
Standard + 5% barley starch	225	685	441	145,1	9,9	43,0	40	I
Late-waxy phase of maturity								
Standard + 3% wheat starch	223	755	486	143,6	10,8	43,4	40	I
Standard + 5% wheat starch	226	740	477	145,7	9,5	42,7	40	I
Standard + 3% rye starch	224	720	464	144,1	10,5	43,5	40	I
Standard + 5% rye starch	227	750	483	146,2	9,2	43,5	40	I

Table 3

Effect of addition of starch derived from immature wheat on moisture and parameters profil texture of wheat bread crumb during storage.

Kind of bread	Storage days	Moisture of crumb (%)	Hardness	Springiness	Cohesivness	Gumminess	Chewiness	Resillence
Wheat flour 100% - Standard	0*	43,88	0,621	1,029	0,639	0,395	0,390	0,462
	1	43,71	0,775	1,013	0,471	0,365	0,383	0,207
	2	43,55	0,943	0,999	0,375	0,363	0,362	0,141
	3	43,21	1,082	0,981	0,335	0,355	0,340	0,122
Early-waxy phase of maturity								
Standard + 3% wheat starch	0	44,55	0,393	1,002	0,834	0,328	0,360	0,542
	1	44,41	0,714	1,001	0,451	0,361	0,345	0,198
	2	43,99	0,724	1,000	0,408	0,323	0,321	0,168
	3	43,66	0,862	0,958	0,333	0,238	0,239	0,130
Standard + 5% wheat starch	0	43,06	0,521	0,998	0,768	0,400	0,399	0,4675
	1`	43,05	0,861	0,975	0,441	0,382	0,366	0,1815
	2	42,84	0,911	0,962	0,360	0,332	0,323	0,131
	3	42,64	0,955	0,946	0,309	0,295	0,279	0,108
Late-waxy phase of maturity								
Standard + 3% wheat starch	0	43,81	0,490	1,163	0,782	0,383	0,440	0,483
	1	43,45	0,826	1,056	0,422	0,350	0,367	0, 181
	2	43,42	0,961	0,947	0,361	0,347	0,323	0,134
	3	43,39	1,020	0,923	0,324	0,328	0,236	0,115
Standard + 5% wheat starch	0	42,95	0,461	1,160	0,645	0,384	0,421	0,474
	1	42,91	0,923	1,051	0,416	0,372	0,399	0,175
	2	42,82	1,133	1,030	0,333	0,365	0,358	0,111
	3	42,70	1,166	0,984	0,305	0,345	0,341	0,109

* 0-day of baking, 1-first day after baking, 2-second day after baking, 3-third day after baking

Table 4

Effect of addition of starch derived from immature rye on moisture and parameters profil texture of wheat bread crumb during storage.

Kind of bread	Storage days	Moisture of crumb (%)	Hardness	Springiness	Cohesivness	Gumminess	Chewiness	Resillence
Wheat flour 100% - Standard	0*	43,88	0,621	1,029	0,639	0,395	0,390	0,462
	1	43,71	0,775	1,013	0,471	0,365	0,383	0,207
	2	43,55	0,943	0,999	0,375	0,363	0,362	0,141
	3	43,21	1,082	0,981	0,335	0,355	0,340	0,122
Early-waxy phase of maturity								
Standard + 3% rye starch	0	43,81	0,453	1,005	0,794	0,359	0,354	0,496
	1	43,77	0,732	1,003	0,472	0,347	0,317	0,222
	2	43,59	0,790	1,000	0,375	0,289	0,293	0,145
	3	43,20	0,848	0,998	0,325	0,261	0,255	0,120
Standard + 5% rye starch	0	43,52	0,400	1,053	0,807	0,346	0,330	0,488
	1`	43,48	0,666	1,005	0,480	0,322	0,325	0,215
	2	43,39	0,865	0,989	0,354	0,319	0,308	0,135
	3	43,03	1,000	0,984	0,328	0,282	0,270	0,111
Late-waxy phase of maturity								
Standard + 3% rye starch	0	43,83	0,392	0,992	0,793	0,369	0,379	0,486
	1	43,61	0,889	0,987	0,478	0,330	0,364	0,216
	2	43,56	1,007	0,963	0,352	0,310	0,327	0,121
	3	43,54	1,120	0,931	0,331	0,283	0,268	0,119
Standard + 5% rye starch	0	43,47	0,449	0,968	0,782	0,382	0,357	0,473
	1	43,05	1,007	0,965	0,428	0,360	0,336	0,175
	2	42,95	1,082	0,960	0,388	0,351	0,317	0,146
	3	42,77	1,110	0,958	0,298	0,314	0,301	0,104

* 0-day of baking, 1-first day after baking, 2-second day after baking, 3-third day after baking

Table 5

Effect of addition of starch derived from immature barley on moisture and parameters profil texture of wheat bread crumb during storage.

Kind of bread	Storage days	Moisture of crumb (%)	Hardness	Springiness	Cohesivness	Gumminess	Chewiness	Resillence
Wheat flour 100% - Standard	0*	`43,88	0,621	1,029	0,639	0,395	0,390	0,462
	1	43,71	0,775	1,013	0,471	0,365	0,383	0,207
	2	43,55	0,943	0,999	0,375	0,363	0,362	0,141
	3	43,21	1,082	0,981	0,335	0,355	0,340	0,122
Early-waxy phase of maturity								
Standard + 3% barley starch	0	43,64	0,568	1,005	0,788	0,448	0,443	0,485
	1	43,59	0,785	0,988	0,438	0,383	0,343	0,183
	2	43,18	0,959	0,980	0,326	0,344	0,330	0,126
	3	43,04	1,198	0,977	0,324	0,325	0,322	0,113
Standard + 5% barley starch	0	43,81	0,623	0,965	0,781	0,486	0,464	0,474
	1`	43,58	0,852	0,958	0,423	0,371	0,371	0,174
	2	43,32	0,969	0,949	0,332	0,361	0,350	0,125
	3	42,96	1,262	0,941	0,319	0,311	0,349	0,119

* 0-day of baking, 1-first day after baking, 2-second day after baking, 3-third day after baking

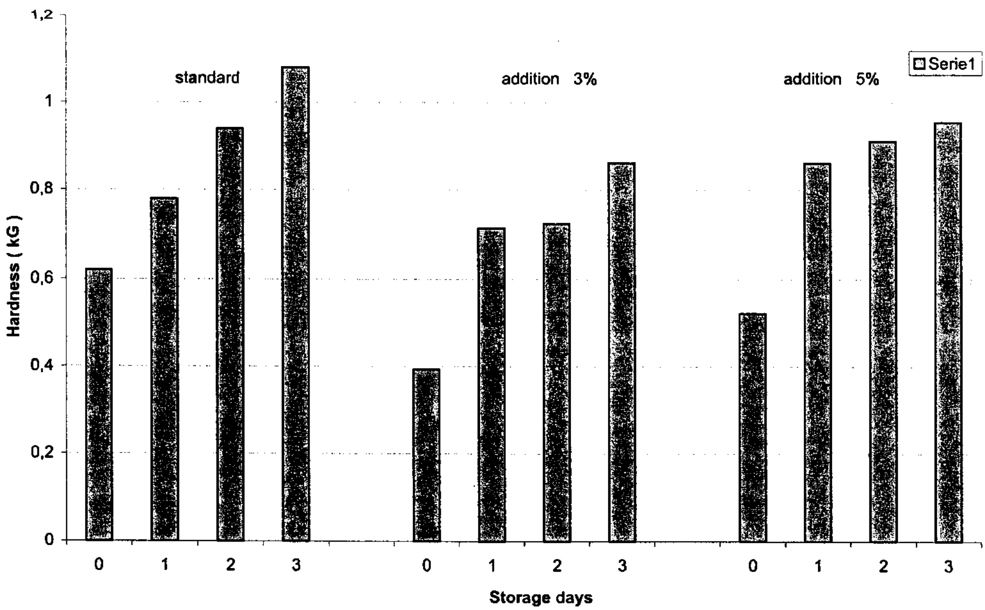

Fig. 1. Effect of addition of starch derived from wheat kernel in early-waxy stage of maturity on hardness of wheat bread crumb.

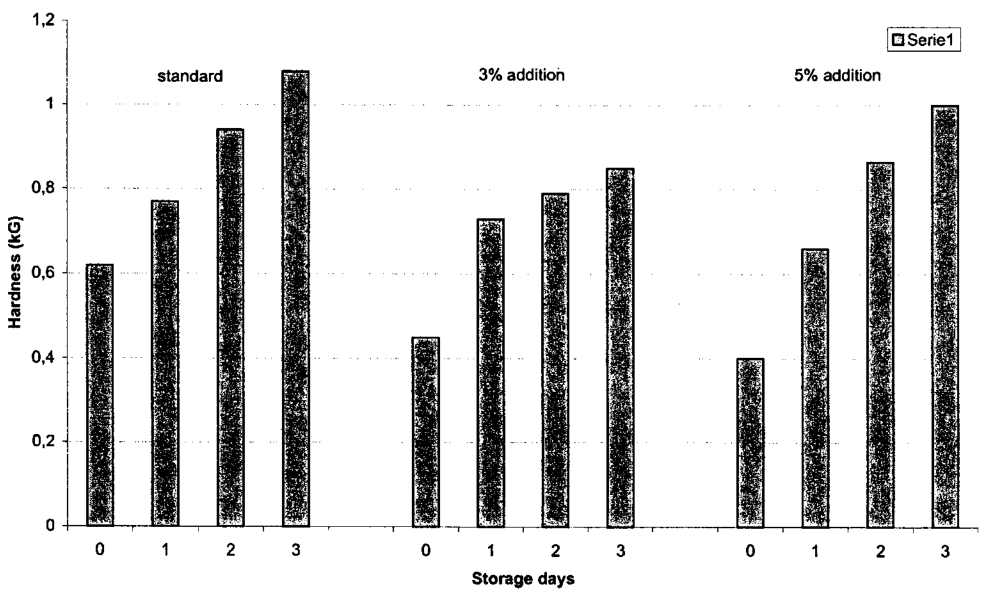

Fig. 2. Effect of addition of starch derived from rye kernel harvested in early-waxy stage of maturity on hardness of wheat bread crumb.

The inhibition of crumb hardening by a starch additive from the immature kernels was probably caused by a greater resistance of the granules of these sorts of starch to the process of swelling and pasting [8]. According to Martin and Hoseney [18, 19], the creators of the latest model of bread staling, this swelling of starch is the main factor defining a degree of hardening of bread crumb – the less swollen granules are and the smaller dilution of starch particles during the process of baking occurs, the smaller surface of contact of starch chains, which flowed out from the granules together with glutenous proteins and the weaker hydrogen bindings netting between protein and starch fractions during the period of storage, which causes the inhibition hardness of crumb.

As a result, the substances, which inhibit swelling of starch granules, also restrict the process of hardening of crumb. Using the starch from the kernel harvested from the field in the early waxy phase of maturity in dough , the addition of such substances seems to be unnecessary. Besides, the smaller swelling ability of the granules of the added starch could cause a greater plasticity of gluten, which according to many authors is the main factor of a longer preservation of freshness of crumb [1, 9, 17, 18].

A lower concentration of amylose gel of a worse sensor characteristic than starch gel could have an impact on a lower hardness of the crumb of the breads with the starch from the immature kernels on the day of baking [25, 26, 27]. As it is known, the starch granules collected from cereal kernels in the early waxy phase of maturity contain a bigger amount of amylopectin in comparison to the starch from mature kernels.

A favourable delay effect on crumb hardening is the least visible while using barley starch (Table 5), which in many scientists' opinion have the same baking values, as wheat and rye starch [3, 11, 12], but it does not derived from bread cereals.

Conclusion

1. The starch additives did not worsen an organoleptic evaluation and the bread of 3% starch isolated from the kernel harvested in the early waxy phase of maturity was characterized by the biggest volume regardless of species of cerals.
2. Both the origin of starch and the amount of the additives did not have any influence on the parameters of crumb texture with the exception of its hardness.
3. All the breads with the starch additives were characterized by a lesser hardness of crumb, both on the day of baking and during the 3 day period of storage compared to the standard bread. However, as far as this characteristic is concerned, the most favourable is a 3% addition of wheat and rye starch from the kernel harvested in the early waxy phase of maturity.
4. The favourable delay effect on crumb hardening was the least visible while using barley starch, which derives from no bread cereals.

5. The wheat and rye starch isolated from cereal kernels harvested in the early waxy phase of maturity should be considered as a natural improver of bread.

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SKROBIA Z NIEDOJRZAŁYCH ZBÓŻ JAKO NATURALNY POLEPSZACZ PIECZYWA

Streszczenie

Do momentu osiągnięcia przez ziarno zbożowe wczesno-woskowej fazy dojrzałości, syntezowane są w nim prawie wyłącznie duże ziarenka skrobiowe typu A o średnicy > 10 μm. W dojrzałych ziarnach zbóż 80 % ogólnej liczby ziarenek skrobiowych stanowią małe ziarenka typu B, a jak wiadomo z badań wcześniejszych, w tworzeniu struktury miękiszu chleba uczestniczą głównie ziarenka duże, które pęcznieją i wchodzą w reakcje ze zdenaturowanym glutenem.

W celu poprawienia tych proporcji, do wypieku chlebów pszennych z mąki typu 550 zastosowano 3 i 5 procentowe dodatki skrobi pszennej, żytniej i jęczmiennej, wyodrębnionej z ziarniaków zebranych z pola zarówno w stanie dojrzałości wczesno jak i późno-woskowej .

Wszystkie chleby wypiekano metodą bezpośrednią, według tej samej receptury. Oznaczono objętość uzyskanych chlebów, wykonano ocenę sensoryczną oraz oznaczono profil tekstury miękiszu chlebów analizatorem tekstury typu TX-XTA, z oprogramowaniem XTR1. Podczas 3 dni przechowywania oznaczono: twardość, spójność, elastyczność, sprężystość , adhezję, żujność i gumowatość miękiszu.

Dodatki skrobiowe nie pogorszyły oceny sensoryczną, a największą objętością charakteryzował się chleb z 3 procentowym udziałem skrobi wyodrębnionej z ziarna zebranego w fazie dojrzałości wczesno-woskowej, niezależnie od gatunku zboża.

Zarówno pochodzenie skrobi jak i wielkość stosowanych dodatków nie wywarły widocznego wpływu na parametry tekstury pieczywa z wyjątkiem twardości miękiszu.

Wszystkie chleby z dodatkami skrobiowymi charakteryzowały się mniejszą twardością miękiszu, zarówno w dniu wypieku jak i podczas 3 dniowego przechowywania, w porównaniu z chlebem standardowym, ale najbardziej korzystny ze względu na tę cechę okazał się 3 procentowy dodatek skrobi pszennej i żytniej pochodzącej z ziarna zebranego w fazie dojrzałości wczesnowoskowej. Efekt ten spowodowany był prawdopodobnie większą opornością ziarenek takiej skrobi na proces pęcznienia i kleikowania (co wykazały badania DSC), a co w skrobi ze zbóż dojrzałych uzyskuje się dopiero po zastosowaniu do ciasta odpowiednich substancji hamujących pęcznienie skrobi. Stosując do ciasta skrobie wyodrębnione z ziarna pszenicy i żyta, zebranego we wczesno-woskowej fazie dojrzałości, dodatek tych substancji wydaje się zbyteczny. Wobec tego skrobię taką zdecydowanie można uznać jako naturalny polepszacz pieczywa.