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EFFECT OF ADDITION OF OAT STARCH COMPONENT ON BREAD QUALITY AND STALING

Abstract

In model pup breads, which were baked with wheat starch and dry, vital gluten, part of the wheat starch was replaced with oat starch (5, 10, 15, 20 % of the total amount of the pup breads). It has been proven that starch fat contained in oat starch has a good effect on improving crumb structure of the model pup breads (40 g), but no such effect has been noticed while baking wheat breads (250 g) with the addition of oat starch.

Introduction

In baking technology of bread and confectionery products more and more attention is being given to a role of starch in forming structures and to its importance in creating flour baking value.

Among other compounds starch-fat complexes contribute to improving crumb structure of bread. These complexes stop retrogradation of both amylose and amylopectin. This process is regarded as one of the main factors causing deterioration of food quality. Among other things, it is responsible for bread staling [6, 10, 13, 21].

Since it is known that after baking, while cooling amylose recrystallizes, scientists think that reducing the amount of amylose in crumb can contribute to its elasticity by adding monoglicerines to dough. During baking monoglicerines become active in forming complexes with amylose causing delay in starch swelling in bread and reducing the amount of free amylose which has flowed out of starch granules [1, 10].

Starch fats also affect the degree of retrogradation. Removing lysophospholipides, which naturally occur in cereal starch, increases the degree of retrogradation. It suggests that they can have some effect on bread staling [11, 13, 14]. The above suggestions were confirmed in our reseach on defatted starches used for baking model pup breads in the starch-gluten system.

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The experiments proved that these starch fats had a crucial effect on both quality and staling of the pup breads [2].

The aim of this work is to present the effect of the starch fat, which naturally occurs in cereal starch, on quality of the pup breads. As the source of this fat we used oat starch, which is characterized by the highest content of fat substances among the studied cereal starches [17, 18].

Material and methods

In the first stage of the experiment our research material consisted of cereal starches – wheat and oat ones. The wheat starch was isolated from wheat of Emika variety by the laboratory method by using a 0.1 % solution of NaCl [5]. The oat starch was isolated by Paton's method [18] from oat of Halny variety and from commercial mixture was called the oat industial starch in the further stages of the experiment. In the investigated starches we determined the basic physicochemical properties such as: raw protein content (N x 5.7) according to [20], total phosphorus content [12] and raw fat content [20], water binding capacity, solubility in water and pasting characteristic of 8.5 % water starch pastes in a Rheotest 2 rotational viscosimeter [4].

In the second stage the research material comprised pup loaves. They were baked with the wheat starch according to the following recipe [3]: 80g starch (starch dry substance), 20 g dry vital gluten (dry substance), 8 g sugar, 3 g salt, 1.5 g dried yeast and 70 ccm of water (at 30°C). The dough yield was 170, and the mass of the bits was 40 g each.

In the pup breads we were gradually replacing the wheat starch with the oat industrial starch increasing its amount form 5 and 10 up to 15 and 20 % and once we replaced the wheat starch with 20 % of the oat starch of Halny variety.

Besides, an attempt was made to bake the wheat bread of 250 g, in which some part of the wheat flour was being replaced with the oat starch and industrial starch in the amounts of 10 % and 20 % of the total mass.

On the day of baking the volume of the loaves was measured in loose material and the indices of their quality were determined according to the standard [19]. During three days of storing up the pup breads in plastic bags in a climatic chamber at the temperatures of 23–24°C and the relative humidity of 64 % we were constantly evaluating bread staling. In our evaluation we also concentrated on crumb penetration measured by a PNR-10 penetrometer and on blue value as in indicator of amylose content in water crumb extract [15].

Results and discussion

On one hand, in comparison with the wheat starch the oat starches were characterized by a decidedly higher content of total phosphorus and raw fat, on the other hand, they had a lower water binding capacity (at 60 and 80°C) and a several times lower solubility in water at the both applied temperatures (Table 1). The analyzed oat starch of Halny variety was characterized by the lowest solubility. It is probably due to the highest content of fat substances in this starch.

Their higher pasting temperature is also connected with the higher content of fat substances in oat starches, because amylose-fat complexes reduce swelling, solubility and outflow of amylose [4, 8, 14]. The proportional rise in pasting temperature with the increase of fat content in the investigated starch confirms this theory (Table 1).

Table 1

Physicochemical properties of oat starches in comparison with wheat starch

Starch characteristic	Wheat starch of Emika variety	Oat starch	
		of Halny variety	industrial starch
Raw protein content (% d.m.)	0.18	0.13	0.21
Total phosphorus content (% d.m.)	0.044	0.071	0.076
Raw fat content (% d.m.)	0.58	1.70	1.03
Water binding capacity (g/1g d.m.)			
at 60°C	8.5	5.4	6.2
at 80°C	9.8	6.4	6.5
Starch solubility in water (% d.m.)			
at 60°C	4.2	0.8	0.6
at 80°C	8.6	0.6	0.8
Pasting temperature [°C]	74	88.5	85
Maximum viscosity [J.U.]	68	119	112
Viscosity after 20 minutes at 96°C [J.U.]	54	106	117
Viscosity after cooling to 50°C [J.U.]	106	114	122

Maximum viscosity of the industrial oat starch was almoust twice as high as that of the wheat starch. Our conclusion is confirmed by the earlier researches on that problem [17, 18].

It is probably due to a much lower oat starch granulation in comparison with wheat starch, and also to a different structure of amylose and amylopectin in oat starch. As we know from Paton's works [18[, oat amylose is characterized by a higher degree of viscisity (2.46–2.99 g/ccm) than wheat starch (2.33 g/ccm), what is attested

by the fact that it is more linear. On the other hand, a lower intrinsic viscosity of oat amylopectin in comparison with wheat one speaks for a higher degree of chain branching.

As opposed to wheat starch a slight increase of viscosity of industrial oat starch after cooling it to 50 degrees Celsius points to a weaker trend to retrogradation of this starch.

Because of these very interesting baking properties of oat starch – namely its high content of fat substances and weak trend to retrogradation – we tried to use the addition of this starch for baking the model starch pup breads.

Any of the used components did not reduce either the mass of the pup breads, or the bread yield , but on the contrary, they had a positive effect on reducing baking loss (Table 2). Taking the results presented in this table into consideration the highest addition of oat starch (15 %) and industrial oat starch (20 %) and the addition of oat starch Halny variety (20 %) seemed the most favourable.

Table 2

Effect of partial replacement of wheat starch with oat starch on selected indices of bread quality (40 g)

Sort of bread	Mass after cooling [g]	Crumb penetration		Bread yield [%]	Total backing loss [%]	Organoleptic evaluation	
		in 1 day	in 4 day			Points	Quality class
Wheat starch - 100% standard	34.7	8.7	1.6	147	13.4	38	I
Wheat starch - 95% + oat industrial starch - 5%	35.3	9.2	2.3	150	11.6	38	I
Wheat starch - 90% + oat industrial starch -10%	34.7	6.8	2.3	148	13.2	36	I
Wheat starch - 85% + oat industrial starch -15%	35.6	8.6	2.5	151	11.0	38	I
Wheat starch - 80% + oat idustrial starch - 20%	35.5	9.8	2.8	151	11.2	38	I
Wheat starch - 80% + oat starch of Halny variety - 20%	35.7	8.9	2.7	152	10.8	37	I

The presence of oat starches in the pup breads had a slight effect on reducing their volume in comparison with the standard bread. The best results were obtained using the 20 % addition of the industrial oat starch; whereas the 10 % addition of this industrial oat starch was the least favourable (fig. 1).

In general, the addition of the oat starch had a positive effect on crumb penetration, especially the 20 % addition of the industrial oat starch; the only exceptionwas the 10 % addition of this starch (fig. 2).

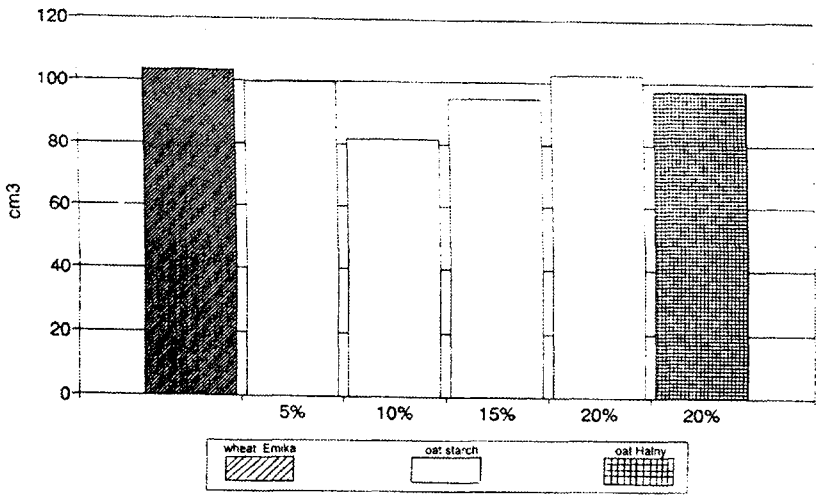

Fig. 1. Effect of various amounts of oat starches on volume of model pup breads.

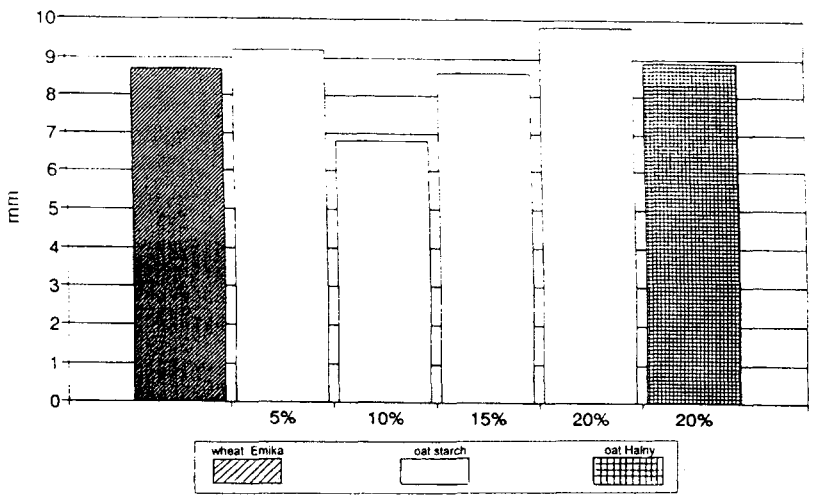

Fig. 2. Effect of various amounts of oat starches on crumb penetration of pup breads on the day of baking.

In comparison with the pup breads baked with the wheat starch, all the pup loaves containing the oat starch were characterized by a softer crumb in four days after baking (table 2, fig. 4). It seems that amylose-fat comlexes reducing swelling of oat starch

(high pasting temperature and low solubility at 80°C) stopped the outflow of amylose from this starch during baking. Additionally, some part of extrinsic monoglicerines in the oat starch could immobilize the amylose contained in the wheat starch by combining together and forming amylose-fat complexes. That is why in the crumb of the pup breads baked with the oat starch there was less amylose subject to retrogradation during their storing. This process could positively affect bread staling.

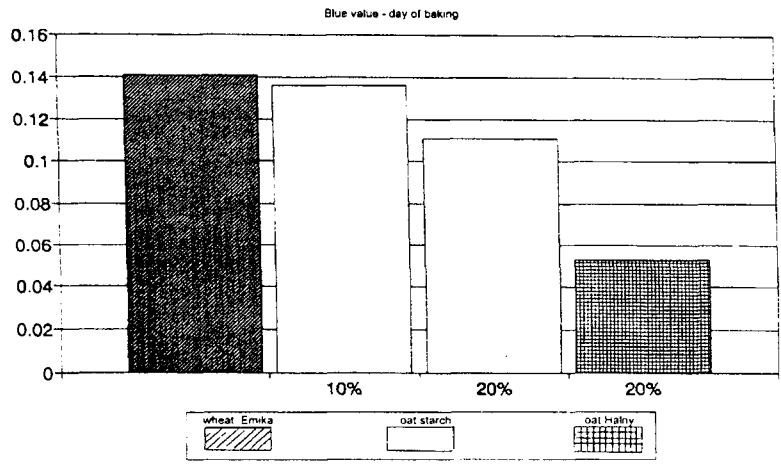

Fig. 3. Slowing down of outflow of amylose to crumb of model pup breads by fat contained in oat starch.

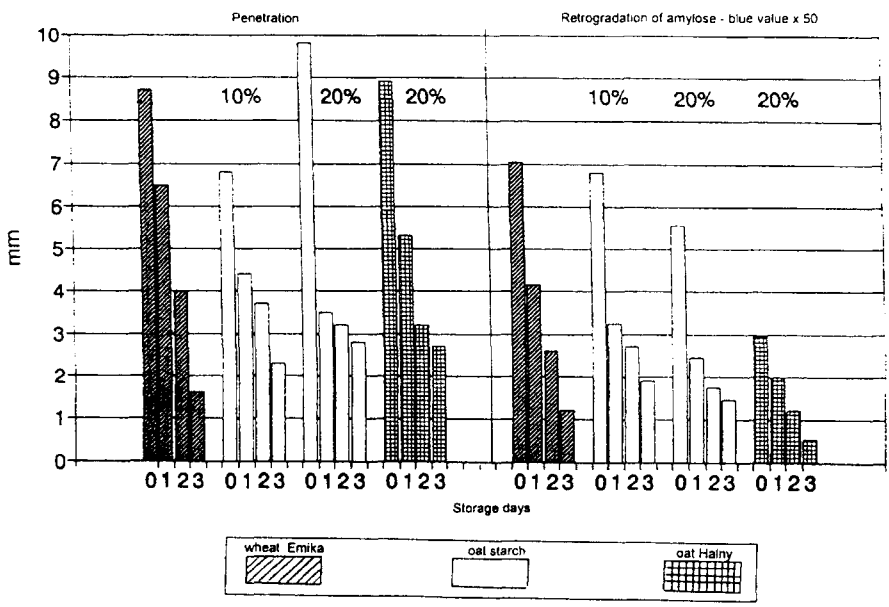

Fig. 4. Effect of various amounts of oat starches on staling of model pup breads.

Although the investigation of structural changes by means of differential scanning calorymetry (DSC) indicates that a slow retrogradation of amylopectin is responsible for bread staling, it is said , however, that concentration of the available amylose accelerates retrogradation of starch and amylopectin [22]. Hence reducing concentration of amylose and its elasticity as a result of adsortive interaction between amylose and fats allows slowing down the process og retrogradation od starch and its fractions [8].

This right assumption can further be confirmed by determination of blue value, which is an indicator of soluble amylose in crumb extract. As one can notice in fig. 3 and 4, on the very day of baking a lower content of amylose was detrmined in the crumb of the pup breads containing the oat starch as opposed to the standard bread and at the same time the decrease of the content of amylose was proportional to the increasing amount of the oat starch in the pup breads. The lowest outflow of amylose to the water crumb extract was from the bread with the 20 % addition of oat starch of Halny variety, which was characterized by the highest content of fat substances among the analyzed starches.

In each case replacing some amount of flour in the wheat bread with oat starch caused increasing baking loss and decreasing bread yield. The volume of the pup breads was also much lower, in particular of those ones containing the 20 % addition of these starches (table 3). As we know, oat starch is characterized by a small size of

Table 3

Effect of partial replacement of wheat flour with oat starch on selected indices of wheat bread quality (250 g)

Sort of bread	Mass after cooling [g]	Bread volume [cm^3]	Crumb penetration		Bread yield [%]	Total backing loss [%]	Organoleptic evaluation	
			in 1 day	in 4 day			Points	Quality class
Wheat flour - type 500 100% - standard	225	658	9.41	3.76	152	10.3	37	I
Wheat flour + oat industrial starch - 10%	220	555	10.75	2.43	150	11.7	30	II
Wheat flour + oat industrial starch - 20%	216	448	5.44	1.27	146	13.6	27	III
Wheat flour + oat starch of Halny variety - 10%	223	618	9.80	2.36	151	10.6	36	I
Wheat flour + oat starch of Halny variety - 20%	221	448	5.07	1.44	149	11.8	27	III

granules measuring (3–18μm) [17] with much worse baking properties than large ones, and probably that is why they had an unfavourable effect on quality of wheat bread, „diluting" gluten, especially in the breads with higher 20 % content of oat starch.

The lower volume of the wheat-oat pup breadsis due to a much lower crumb penetration in comparison with the standard breads.

An interesting fact is that despite the lower volume, the breads baked with the 10 % addition of industrial oat starch and oat starch were characterized by a higher crumb penetration on the day of baking. It seems however, that resistance of the small granules to pasting plays a more important role than the presence of starch fat. This phenomenon has a positive effect on plasticization of gluten. We did not notice any favourable effect of starch fat contained in oat starches on staling wheat breads.

Conclusions

1. In comparison with wheat starch in the analyzed oat starches we determined a higher content of total phosphorus and raw fat, a lower water binding capacity a several times lower solubility in water at 60°C and 80°C and a higher pasting temperature and viscosity, both its maximum value and after cooling to 50°C.
2. The addition of oat starch used for baking the model pup breads increased the degree of bread yield and improved crumb penetration. Despite a slight baling loss, the addition of oat starch contributed to high organoleptic properties.
3. The fat substancess contained in the analyzed oat starch contributed to improving crumb structure by reducing concentration of free amylose and to some extent eliminating its retrogradation. The presence of the 20 % addition of oat starches appeared to be the most effective in the model pup breads baked with wheat starch.
4. We did not notice any positive effect of the starch fat contained in the oat starches on quality and staling of the wheat breads.

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WPŁYW DODATKU SKROBI OWSIANEJ NA JAKOŚĆ I STARZENIE SIĘ CHLEBA

Streszczenie

Ze skrobi pszennej i suchego glutenu witalnego wypieczono modelowe chlebki, w których część skrobi pszennej zastępowano skrobią owsianą w ilości 5, 10, 15 i 20 %. Wykazano, że tłuszcz skrobiowy zawarty w skrobi owsianej wpłynął korzystnie na poprawę struktury miękiszu modelowych chlebków (40 g), natomiast nie wykazał takiego wpływu w przypadku dodatku skrobi owsianej do wypieku chlebów pszennych (250 g).