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PHYSICAL PROPERTIES OF TRITICALE STARCH. PART II. WATER BINDING CAPACITY AND SOLUBILITY OF STARCH

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Key words: triticale starch, water binding capacity, solubility

Starches isolated from 53 Polish triticale breeding lines were tested for water binding capacity and solubility. It was shown that these starches display two-stage curves of water binding capacity and solubility. Among the investigated samples, seven triticale lines exhibit higher solubility which is apparently due to previous hydrolysis.

INTRODUCTION

The model of starch swelling and solubility in water is conditioned by the kind of starch. Starches from tuberiferous plants are highly soluble while cereal starches are much less so because of the stronger bonding inside the starch grains [8, 9]. Unlike the tuberiferous plant starches, the starches in cereals exhibit two-stage curves of water binding capacity and solubility, this being evidence of two sets of internal bonding forces. A different bonding force probably occurs in highly associated and amorphous regions of the starch grain [8, 9]. Regardless of the starch kind, the degree of water binding capacity and solubility are affected by the amylose content, by heat processing of starch as well as by its mechanical damage and chemical modifications [8, 9, 11].

There are no data in literature on the water binding capacity and solubility of starch from triticale, a new cereal. There is also little information about these properties of starch of the parent species of triticale, i.e. wheat and ray Kulp [6, 7] demonstrated that the grinding of cereal grain prior to starch isolation decreased the water binding capacity and increased the solubility of American wheat starches. The starches of soft wheats were marked by higher water binding capacity and greater solubility [6, 7].

The objective of the present research was the study of the water binding capacity and solubility of Polish triticale breeding lines leading to information about the model of swelling and solubility of this starch.

MATERIAL

Information about the starches used in the experiments is given in [3].

METHODS

1. The content of starch dry substance was determined by the drier method [5].
2. The water binding capacity and solubility in water of the starches were determined with the modified Leach method in temperatures of 60, 70, 80 and 90°C [10].

RESULTS AND DISCUSSION

The water binding capacity and solubility at 60°C were determined for all the triticale starch samples (Tables 1 and 3). In view of the fact that statistical analysis revealed a considerable dependence between paste viscosity and starch solubility at 60°C [3], the value of viscosity was taken as the criterion in selecting ten triticale lines for determinations of the water binding capacity and solubility of their starches in the temperature range 70-90°C. The results are presented in Tables 2 and 4 and in Figs. 1 and 2.

As can be seen in Table 1, the studied starches did not differ much as to the degree of water binding at 60°C. The results were in the range 4.99-6.75 g water per 1 g starch dry substance. There was also little differentiation of the separate starch samples in this respect in the temperature range of 60-80°C (Table 2) This fact may indicate a similar kind and force of starch particle bonding in amorphous regions and a similar degree of starch grain crystallinity [9].

A sharp increase of water binding occurred only at temperatures in excess of 80°C (Table 2 and Fig. 1) while the greatest differentiation of samples in this respect was at 90°C.

The results of starch solubility at 60°C were different: the data in Table 3 show the starches to be greatly differentiated as regards solubility already at this temperature (2.24-16.44% dry substance).

Table 1. Water binding capacity of triticale starch at 60°C

Sample no.	Water binding capacity (g H ₂ O) 1 g starch dry substance)	Sample no.	Water binding capacity (g H ₂ O) 1 g starch dry substance)	Sample no.	Water binding capacity (g H ₂ O) 1 g starch dry substance)
1	5.71	20	6.15	39	5.10
2	5.73	21	6.43	40	5.41
3	6.43	22	5.37	41	5.83
4	6.09	23	5.79	42	5.00
5	5.57	24	5.77	43	5.27
6	6.26	25	5.65	44	5.20
7	6.25	26	5.61	45	5.31
8	5.55	27	5.85	46	5.59
9	5.50	28	5.77	47	5.70
10	5.29	29	5.69	48	4.99
11	4.99	30	5.35	49	6.75
12	6.08	31	5.26	50	5.55
13	5.92	32	5.41	51	6.08
14	5.55	33	5.24	52	6.21
15	6.22	34	5.47	53	5.87
16	6.05	35	5.32	mean for triticale	
17	5.87	36	5.96	5.71	
18	5.70	37	5.99	G ₁	5.90
19	6.19	38	5.82	G ₂	5.44

Table 2. Water binding capacity of selected triticale starches in the temperature range 60-90°C (samples ordered according to decreasing viscosity of pastes)

Sample no.	Water binding capacity (g H ₂ O/1 g starch dry substance) at temperature of			
	60°C	70°C	80°C	90°C
36	5.96	6.19	7.41	12.99
49	6.75	6.68	8.99	19.26
2	5.71	6.66	7.60	16.93
21	6.43	7.73	9.70	16.50
6	6.26	7.26	8.44	20.97
23	5.79	6.59	7.49	18.47
51	6.08	7.04	8.60	15.34
14	5.55	8.08	9.29	19.08
30	5.35	6.81	8.12	13.36
29	5.69	7.08	8.49	14.12
mean	5.96	7.01	8.42	16.7
G ₁	5.90	6.68	8.48	15.34
G ₂	5.44	7.04	7.59	12.68

Table 3. Solubility of triticale starch in water at 60°C

Sample no.	Solubility (% dry substance)	Sample no.	Solubility (% dry substance)	Sample no.	Solubility (% dry substance)
1	3.26	20	2.65	39	3.65
2	3.31	21	3.08	40	2.71
3	8.07	22	11.96	41	2.85
4	5.40	23	4.25	42	4.93
5	4.71	24	14.61	43	16.44
6	6.20	25	3.08	44	14.01
7	6.58	26	5.70	45	2.46
8	2.84	27	2.44	46	3.35
9	2.24	28	3.28	47	4.02
10	2.93	29	10.92	48	5.40
11	2.41	30	11.69	49	3.61
12	5.70	31	3.06	50	3.27
13	5.04	32	3.33	51	4.88
14	6.44	33	16.21	52	2.76
15	3.00	34	2.35	53	3.13
16	4.64	35	2.68	mean for triticale 5.16	
17	2.95	36	2.44		
18	2.44	37	3.46	G ₁	2.51
19	5.34	38	5.43	G ₂	3.97

Table 4. Solubility in water of selected triticale starches and of standard „Grana” wheat starches in the temperature range 60-90°C (samples ordered according to decreasing viscosity of pastes)

Sample no.	Solubility (% dry substance) at temperature of			
	60°C	70°C	80°C	90°C
36	2.44	3.05	5.81	16.18
49	3.61	5.51	9.33	31.39
2	3.31	4.39	5.09	27.13
21	3.08	4.54	9.15	24.53
6	6.20	8.30	11.32	45.33
23	4.25	5.38	7.30	34.99
51	4.88	8.71	14.11	40.48
14	6.44	11.32	15.70	50.93
30	11.69	16.26	21.44	40.82
29	10.92	14.89	20.79	40.90
for triticale				
mean	5.68	8.23	12.00	35.26
G ₁	2.51	6.94	8.44	25.54
G ₂	3.97	6.65	9.31	22.31

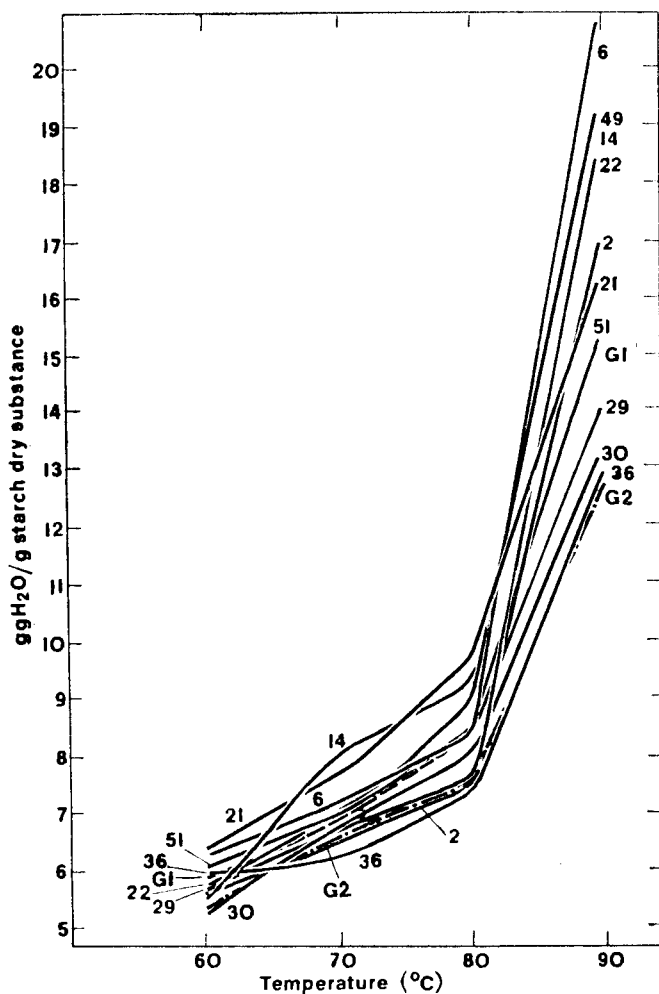


Fig. 1. Degree of water binding by triticale starches during heating of water suspensions at 60-90°C (the numbers next to the curves are sample numbers)

Analogously as in the case of water binding, the solubility of all the starches increased with the increase of temperature as did the differentiation of the samples with respect to this characteristics, attaining the greatest level at 90°C (Table 4 and Fig. 2).

As can be clearly seen in Figs. 1 and 2, when temperature increased from 60 to 70°C the degree of water binding and solubility grew similarly in the various starches. Departures from this regularity appeared only from 80°C, and these are manifest in Figs. 1 and 2 by a considerable increase of curve steepness. This phenomenon may be accounted for by the big changes occurring in the starch grain structure at this temperature, namely by the violent outflow of amylose [1]. When temperature

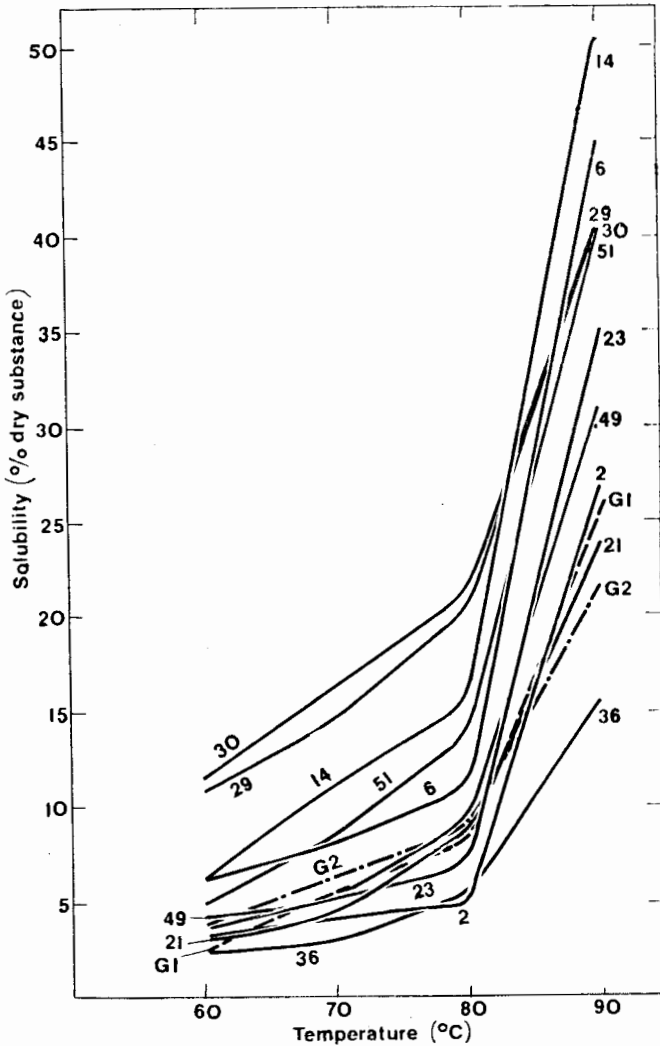


Fig. 2. Solubility of triticale starches during heating of water suspensions at 60-90°C (the numbers next to the curves are sample numbers)

exceeded 80°C the energy level was so high that it led to the breaking of the relatively weak noncovalent bonds in the tangent direction between the radially arranged starch molecules in the crystalline regions [1, 4]. The rise in temperature brought about the diffusion of increasingly large amylose and even amylopectin molecules from the starch grain, hence the highest solubility of starch at 90°C.

The curves for water binding capacity and solubility of starch from triticale are similar for all the samples (Figs. 1 and 2) which indicates that there is a simple dependence between these two functions [8, 9]. At the same time these curves evidence the two-stage swelling of

triticale starch, and hence the existence of two types of bonds in the starch grains of this cereal.

The water binding capacity and solubility of all the studied triticale starches were greater than in the wheat starches analysed by other authors [6, 7] (there were no data concerning rye and triticale starches in the available literature). This was probably due to the different material used for study and to differences in the grinding of grains during starch extraction. According to Kulp [6] grinding disturbs the order of the crystalline structure of starch grains and affects their swelling characteristics by increasing the water binding capacity and solubility of starch.

The most interesting among the studied samples were starches from seven triticale breeding lines (22, 24, 29, 30, 33, 43, 44) which, compared to the others, were much more soluble (Table 3) despite the same degree of water binding in all the samples (Table 1). Although the grains of these starches did not differ visually from starch grains of the remaining lines (microscopic observations), their pastes had a low viscosity [3]. It is possible that the starch molecules of these seven breeding lines underwent enzymatic hydrolysis while still in the cereal grains or during starch extraction.

A comparison of water binding capacity and solubility of triticale starches and of starch from the "Grana" wheat used and standard did not reveal any significant differences in the applied temperature range.

CONCLUSIONS

1. The water binding capacity of triticale starch was the same as that of the standard "Grana" wheat starch.
2. Starches from seven of the investigated triticale breeding lines exhibited considerably higher solubility than the other studied cereal starches.
3. Similarly as other cereal starches, the triticale starches showed a two-stage model of swelling and solubility.

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WŁAŚCIWOŚCI FIZYCZNE SKROBI PSZENŻYTA. II. ZDOLNOŚĆ WIĄZANIA WODY I ROZPUSZCZALNOŚĆ SKROBI

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Streszczenie

Przebadano skrobie wyodrębnione z 53 polskich rodów pszenżyta i dwóch próbek pszenicy „Grana” (użytej jako wzorca) odnośnie do zdolności wiązania wody i rozpuszczalności w wodzie w temp. 60°C. Ponadto w zakresie temperatur 60-90°C wykonano pełną analizę tych właściwości dla 10 wybranych skrobi różniących się znacznie pod względem lepkości ich kleików. Uzyskane wyniki wykazały, że skrobie pszenżyta nie różniły się stopniem wiązania wody w temp. 60°C (tab. 1). Natomiast znaczne zróżnicowanie skrobi w tej temperaturze zaobserwowano podczas oznaczania rozpuszczalności (tab. 3).

W miarę wzrostu temperatury od 60 do 90°C wzrastało zarówno wiązanie wody, jak i rozpuszczalność wszystkich badanych skrobi, jak również wzrastało zróżnicowanie próbek, osiągając najwyższą wartość w temp. 90°C (tab. 2 i 4 oraz rys. 1 i 2). Gwałtowny wzrost wiązania wody i rozpuszczalności skrobi występował po przekroczeniu temp. 80°C (rys. 1 i 2). Krzywe wiązania wody i rozpuszczalności skrobi pszenżyta były dla wszystkich próbek skrobi podobne, co wskazywało na prostą zależność tych dwóch funkcji (8, 9). Jednocześnie świadczą one o dwustopniowym pęcznieniu skrobi pszenżyta, a więc o występowaniu 2 typów wiązań w ziarenkach skrobi tego zboża. Na uwagę zasługiwały próbki skrobi 7 rodów pszenżyta odznaczające się znacznie podwyższoną rozpuszczalnością w stosunku do reszty próbek. Badane skrobie pszenżyta nie wykazywały istotnych różnic zarówno pod względem stopnia wiązania wody, jak i rozpuszczalności w porównaniu ze skrobią wzorcowej pszenicy „Grana”.