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CHARACTERISTICS OF SOLUBLE AND INSOLUBLE FRACTIONS OF GELS PREPARED FROM STARCHES OF VARIOUS BOTANICAL ORIGIN SEGREGATED ACCORDING TO GRANULE SIZE

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ABSTRACT

In the study on pastes: native potato, wheat and corn and those segregated according to granule size as well as pastes of native oat special consideration was given to soluble and insoluble fractions of 2.5% pastes obtained at 90^{o}C. Those fractions were analysed using gel chromatography. Ratio of amylose to amylopectin in supernatant and in sediment were calculated and differences were demonstrated in molecular mass depending on starch origin.

Key words: soluble and insoluble starch paste fractions, molecular mass, gel chromatography, starches: oat, wheat, corn and potato, small, large granules.

INTRODUCTION

Starch gelatinization could be defined as a process which leads to the loss of natural arrangement present in starch granule [Zobel 1988a, Liu et al. 1991]. It could be examined by watching crystallinity changes (from X-

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ray diagrams type A, B or C to V) and decrease of dichroism. In optical or scanning microscope it could be also observed as morphological changes in starch granule and microstructural changes in heated starch dispersions [Bowler et al. 1980, Williams and Bowler 1982]. Damage to natural arrangement requires energy, thus gelatinization could be also followed by DSC [Tester and Morrison 1990, Cookie and Gidley 1992, Yuan et al. 1993]. The process could be also measured in terms of swelling changes, solubility and viscosity of starch pastes [Miller et al. 1973, Collison 1968, Doublier 1981, Zobel 1984, Langton and Hermansson 1989, Laundry et al. 1986, Radosta et al 1991].

Methods described above do not allow to identify and quantify substances which leak from granules during gelatinization. This is why gel chromatography was used to study soluble and insoluble fractions (supernatant and precipitate) during this process. Due to lack of information in literature concerning percentage of amylose and amylopectine and molecular weight of amylose leaking from granules and residing in precipitate after centrifugation of pastes made from starch of various botanical origin and segregated according to granule size, this problem has been chosen as the aim of the study.

MATERIALS AND METHODS

The following samples were used for the study: potato, wheat, corn and oat industrial starches. The fractions were obtained by sedimentation from the height of 14.5 cm in destined water:

1. for potato starch:
- large (L) after 25 min sedimentation
- medium (M) after 90 min sedimentation
- small (S) made up the residue obtained after centrifugation of the M-fraction sediment dispersion

2. for wheat and corn:
- large (L) after 90 min sedimentation
- small (S) made up the residue obtained after centrifugation of the M-fraction sediment dispersion

Gelatinization was achieved by suspending 0.6 g of cereal or 0.3 g of potato starch in 24 cm^3 of distilled water and mixing the suspension at 230 rpm for 0.5 h at 90° C. Starch paste was centrifuged for 15 min at 1250 x g. In the obtained supernatant (potato paste supernatant was diluted 1:2 with 0.005 M NaOH) total carbohydrate content was determined by anthron method [Morris 1948] and starch solubility in the prepared paste was calculated on this basis. 0.6 g of the sediment obtained by centrifugation was dissolved in 4 cm^3 of 90% DMSO. Before SEC supernatants and sediments were centrifuged for 5 min at 11324 x g. For SEC analysis 4 columns filled with Sephacryl gel were used: pre S-200 (1.6 x 50 cm), S-200 (1.6 x 62 cm), S-500 (1.6 x 90 cm), S-1000 (1.6 x 88 cm). Following conditions were applied: injection of 2 cm^3 of sample, aqueous 0.005 M NaOH as eluent. The 5 cm5 big fraction were analysed for total carbohydrate by anthrone analysis for obtained chromatogram and also iodine stainig at 525 and 640 nm was used [Praznik et at. 1983, Praznik et al. 1997]. Nonlinear regression was performed to fit the Gaussian distribution for peaks visible in chromatogram Using the evaluated parameters it was possible to count linear to branched fraction and molecular weight averages (Mw).

RESULTS AND DISCUSSION

Supernatant and precipitate of centrifuged pastes prepared from starches of various botanical origin segregated according to granule size were studied. Solubility (Table 1) of native potato starch as well as of its fraction was the highest and that of corn starch the lowest of all studied samples. Values for wheat and oat starches were similar. The lowest solubility of corn starch could be caused not only by high content of small granules type B (<10 μm) [Achremowicz et al. 1997] but also the highest amount of free fatty acids [Melvin 1979]. High solubility of potato starch is known as being due to loose structure type B in comparison with type A of cereal starches [Collison 1968, Launay et al. 1986]. It was observed that small granules fraction was more soluble than large granules fraction and native starch. This property could be caused by higher crystallinity of small granules and so their resistance to gelatinization [Gambus et al. 1993, Wong and Lelievre 1982].

Table 1. Solubility and SEC analysis of supernatants of starch paste obtained at 90°C

Type of starch samples	Solubility [%]	AP-like glucans content [%]	AM-like glucans content [%]	M_w of AM-like fraction [g/mol]
Potato				
Native	100,00	33	67	$9{,}9 \cdot 10^6$
Large	100,00	49	51	$5{,}4 \cdot 10^6$
Medium	93,30	33	67	$7{,}5 \cdot 10^6$
Small	93,30	27	73	$3{,}2 \cdot 10^6$
Wheat				
Native	49,60	4	96	$3{,}7 \cdot 10^5$
Large	55,12	16	84	$4{,}7 \cdot 10^5$
Small	44,50	7	93	$1{,}5 \cdot 10^6$
Corn				
Native	5,36	6	94	$5{,}7 \cdot 10^5$
Large	6,00	2	98	$3{,}8 \cdot 10^5$
Small	-	3	97	$4{,}5 \cdot 10^5$
Oat				
Native	52,70	33	67	$9{,}9 \cdot 10^5$

Starch paste supernatant obtained at 90°C was examined by means of gel permeation chromatography. Based on the results percentage of branched (AP) and linear (AM) fractions and weight average molecular weight of amylose (Fig. 1, Table 1) were estimated. Among native starches the highest amount of branched fraction was determined for supernatants of potato and oat starch pastes, and the lowest one for wheat and corn starches. Amylopectin content determined in soluble fraction of oat starch is much higher than in other cereals which is explained by Tester and Karkalas [1996] to originate from fragility of the granules during swelling and gelatinization. Consequently during gelatinization leakage of amylose takes place concurrently with breaking apart of amylopectin fragments. In the supernatant of large granules potato starch paste percentage of branched molecules was lower than in other fractions of this starch. The same relation was observed for wheat starch. Among native starches the highest average molecular weight was obtained for potato starch amylose (Table 1) and lower values for cereal starches, which is consistent with the previous reports [Zobel 1988 a]. Mw of amylose determined in supernatant of potato starch was higher in large granules fraction than in the small ones. No such relation was found for other starches.

Due to low amylopectin leakage during gelatinization of wheat starch, percentage of branched fraction in precipitate of this starch was high and equalled 71%. The reverse dependence was observed in case of oat starch. Molecular weight of linear fraction determined for precipitate of wheat and oat starch was higher in comparison with molecular weight of amylose present in supernatant of these starches (Table 2). Beside branched and linear fraction in precipitate of wheat starch paste produced from large and small granules some low-mass carbohydrates were detected (27%) with masses beneath 3000 g/mol. Low-mass carbohydrate fraction was also present in oat starch precipitate, but in much smaller amount.

Fig. 1. SEC analysis of native starch pastes supernatants obtained at 90°C

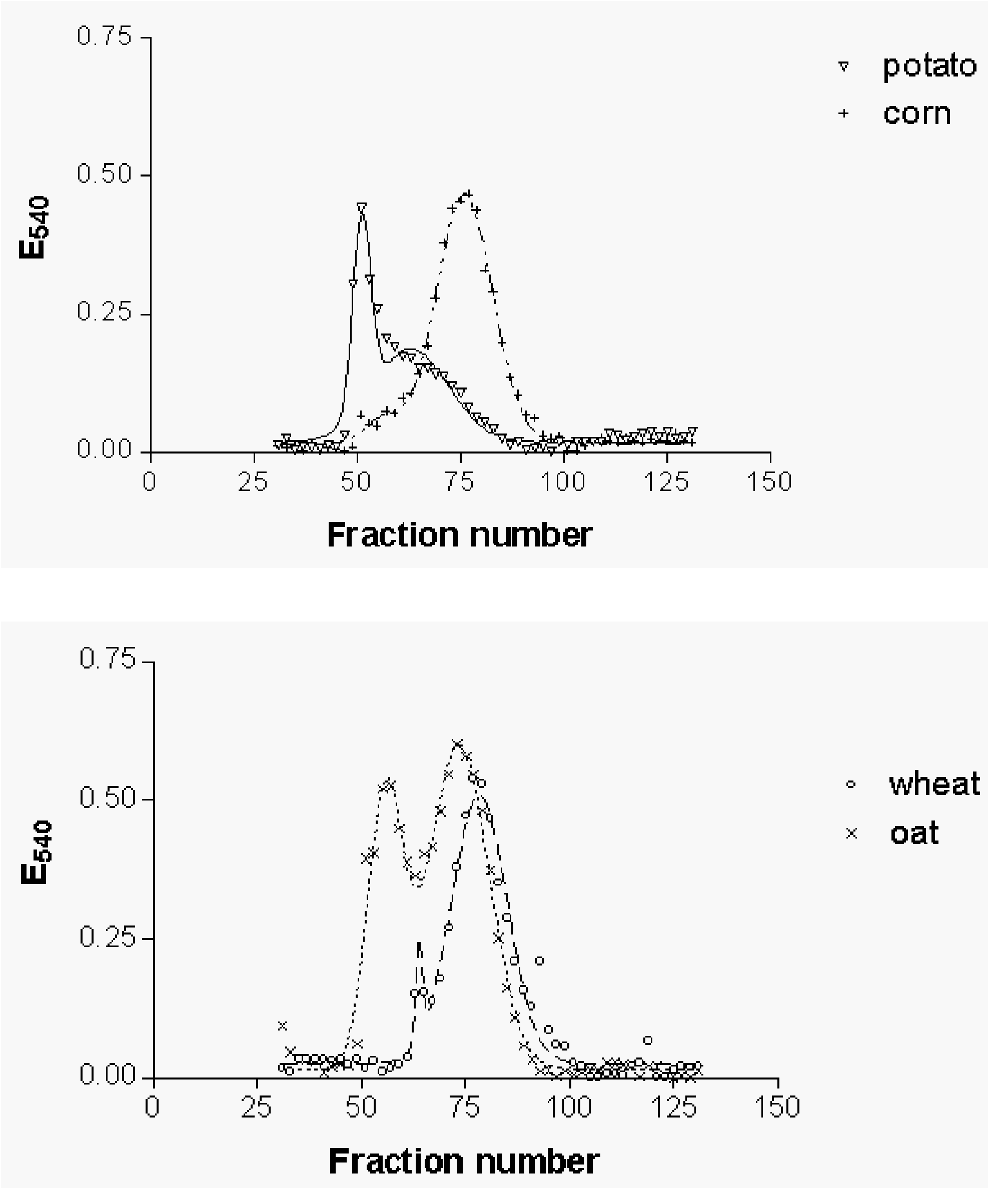

Table. 2. SEC analysis of starch paste sediment obtained at 90°C

Type of starch samples	AP-like glucans content [%]	AM-like glucans content [%]	Low mass carbohydrates content [%]	M_w of AM-like fraction [g/mol]
Wheat				
Native	71	29	0	$1{,}5 \cdot 10^6$
Large	33	40	27	$4{,}1 \cdot 10^6$
Small	34	39	27	$2{,}4 \cdot 10^6$
Oat				
Normal	33	63	4	$2{,}4 \cdot 10^6$

Insoluble components of native oat starch present in precipitate were similar to those from small granules fraction of wheat starch (Fig 2). This could be related to high content of type B granules and phosphorus compared to other cereal starches and their fractions differing in granularity [Achremowicz et al. 1997].

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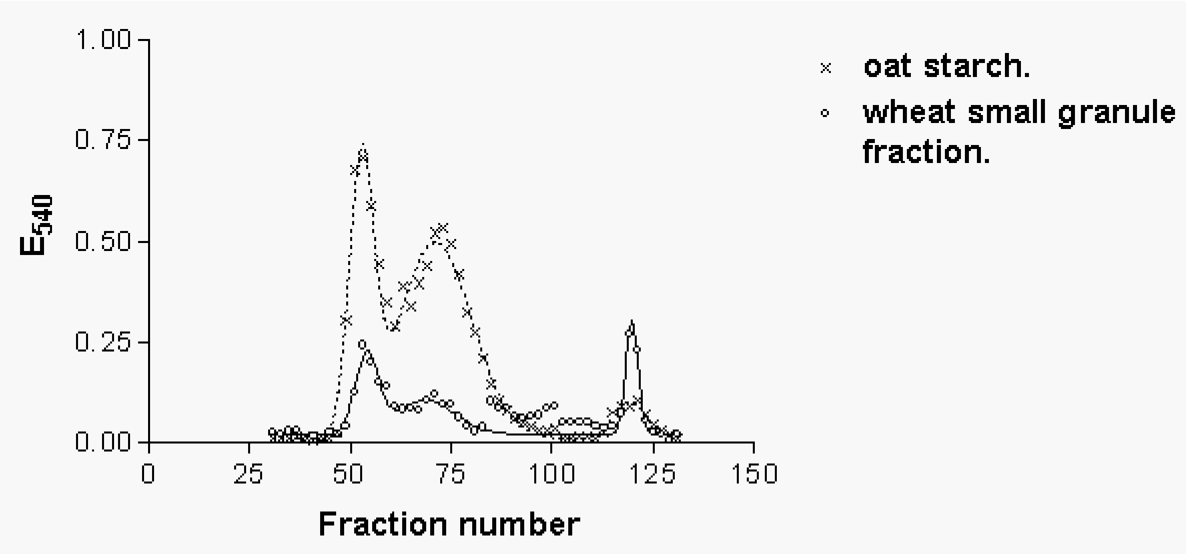
Fig. 2. SEC analysis of starch paste sediment obtained at 90^{o}C



CONCLUSIONS

1. Small granule fractions of all studied starches showed lower solubility at 90°C than large granule fractions and native starches
2. Despite various botanical origin, supernatant of native starches: oat and potato was characterised by the same ratio of linear to branched glucans, higher than for other cereal starches
3. In spite of differences in solubility of wheat and corn starches, both native and segregated according to granule size, ratio of linear to branched glucans was close.
4. Weight average molecular weight of linear glucans in supernatant of potato starch paste and its fractions was much higher than for cereals.
5. In oat and wheat starch pastes sediments not only branched glucans but also high-molecular linear and low molecular oligosacharides were observed, which could probably be freed by DMSO action.

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