Barley Starch. IV. A Study of the Cooking Viscosity Curves of Twelve Barley Genotypes[1]

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ABSTRACT

Starch was isolated from 12 barley genotypes by a modified wet-milling technique. Brabender amylograph curves indicate that hull-less varieties have a higher viscosity than their covered counterparts. Only with Compana was there a substantial difference in the amylose-amylopectin ratio, although in general the hull-less varieties appear to be more waxy. These results suggest that it may be possible to create new starch types by recombination of marker genes.

Barley is one of the most important feed grains in the Intermountain area and recently has become the raw material for the manufacture of starch. Preliminary investigation of the production of barley starch (1,2) indicated that there might be greater differences in the starch from barley varieties than has been observed in other cereal grains. The present investigation was made in an attempt to verify this observation and to study the effect of genetic differences on characteristics of the starch. When appropriate isogenic lines were available, they were included in the study on the basis that the association of starch characteristics to a visible phenotype would permit genetic manipulation without extensive starch analysis. Goering et al. (3) reported that the only significant differences observed in 30 barley genotypes was in the Brabender cooking curves, although in a few instances a slight difference in iodine affinity was observed.

This study is a re-examination of these properties on some of the barley genotypes reported previously (3) to be unusual. A different procedure, which eliminates some potential artifacts, is used for starch separation in the present study.

MATERIALS AND METHODS

Preparation of Starches

Since it was observed that production of starch from flour by the alkali process can create artifacts if extreme care is not observed during preparation, all barley starches used in this study were prepared by the usual wet-milling technique after 48 hr. of steeping with 0.2% potassium metabisulfite (4). All starch samples were screened through 400-mesh screen and centrifuged in a solid basket; the thin dark layer at the top of the basket was removed with a spatula, and the starch suspended in cold alkali at pH 11.0. After standing overnight in the cold room, the starch was washed to remove excess alkali, neutralized with HCl, centrifuged, and dried in a convection oven at 50°C.

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Determinations

Protein content was determined by a modified Kjeldahl method (5, p. 12) (conversion factor, 6.25). The samples were ashed in a muffle furnace according to the usual procedure (5, p. 284). The total free fat was determined by ether extraction (5, p. 287).

Brabender viscosity curves were run at the 8% level by the procedure described by Smith (6).

Iodine affinity was determined by the procedure of Schoch (7).

RESULTS AND DISCUSSION

Chemical composition of the 12 barley starches is given in Table I.

With the exception of Glacier, all hull-less types have a lower iodine affinity than the covered types, suggesting that the gene responsible for the hull-less type also lowers the amylose content. Previous data (3) indicated that hull-less types have a higher solubility, which would also fit the general picture. No consistent pattern was observed for swelling power, phosphorus content, or solubility in dimethyl sulfoxide (3).

Covered vs. Hull-less

Starch from derived hull-less isogenes of four commercial varieties was used in this study.

Since different starch sources show different rates of hydrolysis with pancreatic amylase (8,9), it is highly probable that different varieties of the same starch source may show differences, possibly due to granule structure or to molecular composition. Therefore, isogenic lines should be fed to animals as pure starches to see if differences exist. If so, a study could be made to see if there is any correlation between molecular structure and results of feeding trials. In such an experiment conducted by Newman et al. (10) with whole barley, hull-less Glacier was found equal to Glacier as a basal for pigs, whereas hull-less Compana was found definitely superior to the covered variety. Our data indicate that hull-less Compana is more waxy than either covered Compana or the two Glacier varieties. Therefore, this difference in feeding results could be explained on the basis that amylopectin is

TABLE I. CHEMICAL COMPOSITION OF THE BARLEY STARCHES

Starch Variety	Ash %	Fat %	Protein %	Iodine Affinity %
Hull-less Compana	0.13	0.33	0.55	3.9
Compana	0.19	0.32	0.33	4.3
Hull-less Glacier	0.13	0.26	0.38	4.4
Glacier	0.19	0.53	0.44	4.3
Betzes	0.19	0.28	0.33	4.3
Shrunken Betzes	0.20	0.29	0.22	3.8
Betzes X UM 570	...	...	0.22	4.1
Hull-less Titan	0.18	...	0.33	4.3
Titan	0.16	0.12	0.33	4.5
short-awn hull-less	0.24	...	0.44	4.2
short-awn covered	0.13	...	0.44	4.3
thin-hulled	0.27	0.26	0.27	4.6

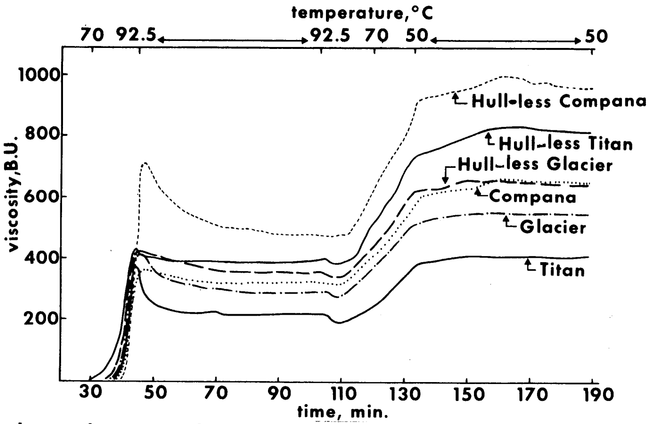

Fig. 1. Brabender amylograms on barley starch for covered and hull-less isogenes (8% level).

more readily available to animals, a concept that seems to be reasonably well established (8,11).

The Brabender curves for the covered and hull-less isogenes are shown in Fig. 1. It is interesting that in every case the hull-less isogene has a higher viscosity than the covered counterpart. In addition, there is a wide difference in the viscosity curves, hull-less Compana showing the most and covered Titan the least viscosity. This suggests that by proper breeding even greater differences could be obtained.

Shrunken Endosperm and High-Diastic-Power Betzes

Brabender curves for Betzes, a shrunken-endosperm mutant from Betzes, and a selection from the cross UM 570 X Betzes, F6, are presented in Fig. 2.

The average kernel weight of Betzes as grown at 11 locations was 33.9 mg., whereas the thin mutant at the same locations had an average kernel weight of 19.5 mg. From Table I it is observed that the shrunken Betzes starch is considerably

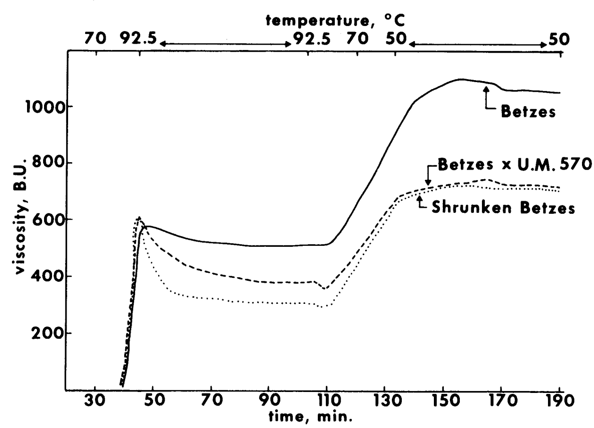

Fig. 2. Brabender amylograms for barley starch from Betzes, Betzes X UM 570, and shrunken Betzes (8% level).

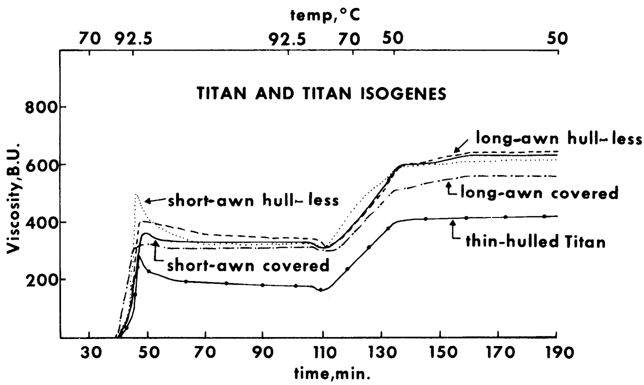

Fig. 3. Brabender amylograms for barley starch from Titan and Titan isogenes (8% level).

more waxy than the regular Betzes. The shape of the Brabender curves gives some indication of this, as the granules appear to be less stable than those of the regular Betzes.

Titan and Titan Isogenes

Brabender curves for Titan and its isogenes are given in Fig. 3. These isogenes were all from the same year and location. There is some difference in the long-awn hull-less and the covered, as shown in the data in Fig. 1, although the same trend is observed in that the hull-less has the higher viscosity of the two samples. We note very little difference in the short-awn hull-less and covered, suggesting that the differences observed in hull-less and covered for long-awn types do not appear in the short-awn. This should be investigated further with other varieties. The thin-hulled Titan curve is substantially different from the others. Other thin-hulled varieties should be investigated to see if this is a general characteristic.

CONCLUSIONS

Some genetic differences were observed among the 12 barley genotypes. In general, the hull-less varieties have a higher viscosity than the covered types. Only in Compana was there a substantial difference in the amylose-amylopectin ratio, although in general the hull-less varieties appear to be more waxy.

Some differences seem to be associated with certain phenotype characteristics such as two-row vs. six-row head character, covered vs. hull-less kernel, genetic thin vs. normal kernels, and thin-hull vs. normal kernels.

The isogenic-associated characteristics should be transferable without resort to starch measurements and large-scale seed increases. It might be possible to create new starch types or to maximize or minimize characteristics reported on here by recombination of marker genes. If one wanted a very viscous starch, one might start with two-row Betzes and increase its viscosity by incorporating hull-less gene and possibly other genes such as the orange lemma. To obtain a starch with low viscosity, one could start with six-row Titan and incorporate the thin-hull gene. Further study might suggest incorporation of other genes to lower viscosity.

If we assume that the amylose and amylopectin in these barley starches are normal, this work suggests that these observed variations may be primarily the result of granule structure. It would appear that barley is an ideal substrate for a study of starch properties.

Acknowledgments

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