Effect of Variety and Growth Conditions on the Ability of Moist Oat Caryopses to Hydrolyze Triglycerides[1]

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ABSTRACT

Nine early and 11 midseason oat cultivars grown at 18 locations in the central and eastern United States were used to evaluate the ability of whole moist caryopses immersed in soybean oil to hydrolyze the oil. Significant differences in cultivars for mean of percentage hydrolysis were observed in both early and midseason groups. Percentage hydrolysis was correlated negatively with groat percentage for both early and midseason oat cultivars. Percentage hydrolysis was negatively correlated with the caryopsis weight for early cultivars. Oat caryopses harvested 15 days postanthesis had greater hydrolytic activity per unit weight than those harvested 30 days postanthesis. The hydrolytic activity of oat line B605-1085 varied significantly from year to year and was markedly higher in 1988, a very dry year.

Martin and Peers (1953) first demonstrated that much of the lipase in oat (*Avena sativa* L.) is on the surface of the caryopsis. Urquart et al (1983) reported that most of the lipase of oat was associated with the aleurone layer. Ekstrand et al (1992) reported the lipase activity of the oat embryo was greater than that of the aleurone layer, which was greater than that of the endosperm. Frey and Hammond (1975) reported significant differences among cultivars for lipase activity of ground oat samples and suggested that the lipase of oat caryopses seemed to be genetically controlled. Other researchers (Lee and Hammond 1990, Hammond and Lee 1992) suggested that moist oat caryopses constituted a natural lipase bioreactor that could be used to hydrolyze fats and oils. They also reported considerable variation in the lipase activity among oat cultivars.

This article reports the effect of cultivar and conditions (early and late harvest and growth year) on the ability of moist oat caryopses to hydrolyze the triglycerides of soybean oil.

MATERIALS AND METHODS

Thirty-three early and 36 midseason oat cultivars grown in Ames, IA, in 1990, were used to evaluate the ability of moist caryopses that were immersed in soybean oil to hydrolyze the oil. On the basis of this evaluation, nine early and 11 midseason cultivars representing a range of lipase activities were obtained from oat researchers for further study. Samples of these cultivars were grown in 1990 at five locations for early cultivars and 11 locations for midseason cultivars. Yield (bushels per acre), test weight (pounds per bushel), groat percentage, and protein percentage of the oat cultivars were reported for some of the locations by Halstead and Rines (1990). For groat weight, 100 seeds were dehulled manually and weighed.

Hydrolytic activity of seed from B605-1085 grown at Ames, IA, in 1981, 1987, 1988, 1989, and 1990 was determined for each year to test the effect of year on hydrolytic activity. These evaluations were done in 1990. Seed was stored at 4°C and 40% rh after harvesting and proper drying until evaluated. To compare the effect of growth period, caryopses of oat cultivar B605-1085 and Y907-5-5 grown at Ames, IA, in 1990, were harvested 15 and 30 days postanthesis.

Oat samples were dehulled with an impact-type dehuller (A-4910, Wintersteiger Gesellschaft, Reid, Austria). The ability of the dehulled caryopses to hydrolyze the oil was determined in duplicate by the titrimetric method described by Lee and Hammond (1990). Ten grams of oat caryopses were moistened with 2 ml of water and immersed in 10 g of refined soybean oil (Crisco, Proctor and Gamble Co., Cincinnati, OH). After five days at 40°C, 0.2 g of the oil was dissolved in 15 ml of diethyl ether-methanol (2:1, v/v), and a 5-ml aliquot was titrated to pH 9 with aqueous 0.01*N* sodium hydroxide solution. Hydrolytic activity was reported as the percentage of ester groups hydrolyzed. Percent hydrolysis can be converted to meq/10 g of sample by multiplying by 0.3434.

The means of the duplicate determinations of hydrolytic activities of the early and midseason varieties were subjected to an analysis of variance with locations considered as replicates, and the cultivar-location interaction mean squares was used as the denominator of the *F*-test to test for significance between cultivars. Statistical analysis was done using the general linear model (GLM, ver. 6.06, SAS, Cary, NC). The cultivar-location mean squares were used to compute values for Duncan's multiple range tests for use in comparing mean hydrolytic activity of cultivars. Simple correlation between lipase and other production and agronomic traits were computed across cultivars within locations using mean values for the variables. The *r* values for each location were tested for homogeneity and the within location correlations for pairs of traits were pooled by converting to *z* values, averaging, and reconverting the average to a correlation coefficient. Correlations were tested for significant deviation from zero by using the pooled degrees of freedom. The effect of cultivar, harvest date, and growth year on the extent of hydrolysis was tested by applying a least significant difference test to individual points or the means of each treatment.

RESULTS AND DISCUSSION

Early and Midseason Nurseries

The effect of cultivar hydrolytic activity was highly significant ($P < 0.01$) when tested against cultivar-location interaction for both the early and midseason oat cultivars. Early oat cultivars, when averaged across locations, fell into two distinct groups for hydrolytic activity (Table I). Group I ranged from 52.7 for MN 87187 to 47.6 for PA 8393-15050, and Group II ranged from 33.1 for IL 83-7641-1 and Don to 28.7 for IL 86-1973. The highest oat line mean for hydrolytic activity was 1.8 times greater than the lowest.

When lipase activities for the midseason cultivars were averaged across the 12 locations, they divided into several groups (Table II). PA 8393-1500 gave the greatest activity at 61.3, whereas ND 8625585 gave the lowest at 32.3. Other cultivars with high hydrolytic activity were OH 1022, PA 8383-11138, and PA 8494-

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11717. The highest oat line mean for hydrolytic activity was 1.9 times greater than the lowest.

The hydrolysis percentages after five days (Tables I and II) do not reflect the maximum rate of hydrolysis of the samples. The initial rates are generally two- to threefold greater than the percentage of hydrolysis for five days. The rates decline with time because of the accumulation of reaction products (Lee and Hammond 1990). A five-day time period was chosen because it emphasized differences in the relative hydrolytic capacity of the cultivars and was indicative of the potential commercial value of the cultivars as a lipase source for hydrolyzing fats.

Table III gives the correlations between hydrolytic activity and the weight of 100 caryopses, as well as several agronomic parameters for the locations reporting (Halstead and Rines 1990). Percentage of groat was negatively correlated with hydrolytic activity for both the early and midseason nurseries, and the correlations were significantly different from zero. The weight of 100 caryopses was negatively correlated with hydrolytic activity for the early nursery, and the correlation was significantly different from zero. Seemingly, when the caryopses are small and make up a smaller percentage of the grain or weigh less per caryopsis, their hydrolytic activity per gram of groats tends to be greater. Probably, this is because small caryopses have a greater surface area, and hence more surface lipase, per unit weight.

Early and Normal Harvest

As shown in Figure 1, hydrolytic activity was significantly greater in the material harvested early. Early harvest resulted in lightweight groats, and in agreement with the correlations noted for the early and midseason nurseries, lightweight groats have more hydrolytic activity per unit of weight. Evidently, the lipase occurs on the surface of the caryopses early in grain development, so the poorly developed caryopses have more hydrolytic activity per unit weight.

With lipase-rich oats, the initial slope of hydrolysis versus time is significantly greater, and the plateau reached at the finish of hydrolysis is significantly higher (Fig. 1). If moist oat caryopses are used to hydrolyze fats and oils, it is important to have the hydrolytic activity as high as possible. At both harvest times, Y907-5-5 achieved significantly greater hydrolysis than B605-1085. Y907-5-5 was identified as having high hydrolytic activity by Lee and Hammond (1990), and its activity was greater than that of any of the early and midseason cultivars. B605-1085 has a hydrolytic activity typical of the least active cultivars in the early and midseason sets.

Harvest Year

Significant differences in hydrolytic activity of B605-1085 between years was noted in Figure 2. The hydrolytic activity of

TABLE I
Mean Hydrolytic Activity and Caryopses Weight for Early Oat Lines

Strain	% Hydrolysis	Weight (g) 100 Caryopses
MN 87187	52.7 a[a]	2.38
P8646B1-X-11-4	49.0 a	1.88
PA8598-8415	48.5 a	2.30
MN 87194	48.2 a	2.50
PA 8393-15050	47.6 a	2.07
IL 83-7641-1	33.1 b	2.33
DON	33.1 b	2.45
ANDREW	32.1 b	2.35
IL 86-1973	28.7 b	2.75

[a] Means with the same letter are not significantly different at $P < 0.05$.

TABLE II
Mean Hydrolytic Activity and Caryopses Weight for Midseason Oat Cultivars

Strain	% Hydrolysis	Weight (g) 100 Caryopses
PA 8393-1500	61.3 a[a]	2.39
OH 1022	60.4 ab	1.89
PA 8393-11138	60.0 ab	2.20
PA 8494-11717	56.7 a–c	2.09
OH 1007	56.3 bc	2.10
P76134D3-27-3-5	52.6 cd	2.41
WI X5259-1	49.4 de	2.13
IA B605X	47.2 e	2.16
ND 861246	37.0 f	2.14
SD 85009	35.1 f	2.38
ND 8625585	32.3 f	2.12

[a] Means with the same letter are not significantly different $P < 0.05$.

TABLE III
Correlations of Hydrolytic Activity with Production and Agronomic Traits for Oat Cultivars

Maturity	Yield (bu/ac)	Test Weight (lb/bu)	% Groat	% Protein	Weight (g) 100 Caryopses
Early	0.079	0.076	−0.520*[a]	0.112	−0.601*
Midseason	−0.134	−0.073	−0.232*	0.161	−0.024

[a] Significant at $P < 0.05$ level.

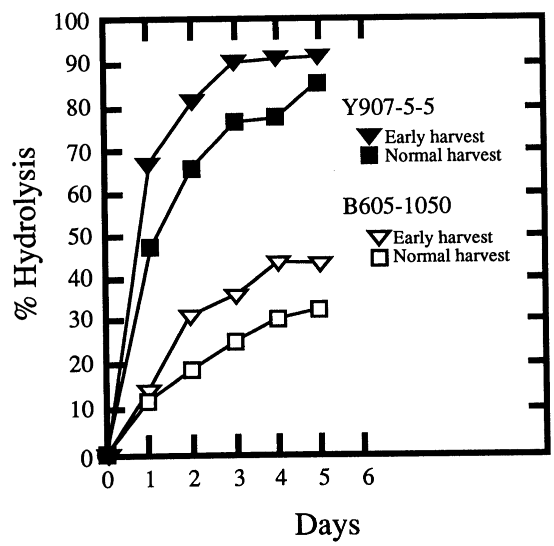

Fig. 1. Effect of early and normal harvest date on the percentage of triglyceride hydrolysis versus reaction time in days for two oat cultivars. Harvest dates, cultivars, and initial slopes for the two cultivars were significantly different at $P < 0.05$.

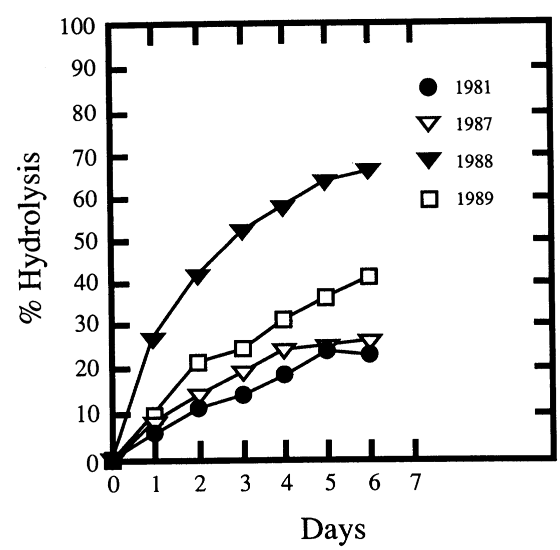

Fig. 2. Effect of several growth years on the percentage of triglyceride hydrolysis versus reaction time in days for B605-1050 oats. All years were significantly different at $P < 0.05$.

B605-1085 grown in 1988 was much greater than that of any other year. A severe drought occurred in 1988, but oats in general produced well; the grain had a light color and was free from fungus. Storage conditions for the oat samples were optimum for maintaining germination, but hydrolytic activity of groats declines with long-term storage. Lee (1989) found that oats, when stored for one year, lose 40–60% of their hydrolytic activity.

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