Protein Quality of Oat Varieties

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Comparison of 16 varieties of oats was made by feeding them to groups of rats as their sole source of protein. Consistent differences were observed between the nutritive values of some of the varieties in four experiments. The levels of lysine and methionine in the protein of the oat varieties were determined but there was no correlation between the weight gains of the rats fed these oat samples and the levels of lysine and methionine in the grain. Time and location of planting of oats were not important factors in determining the nutritive value of the oat protein.

The growth-promoting values of the proteins of various grains have been compared by a number of workers. Less information is available concerning differences in the growth-promoting value of the total protein of the seeds of different varieties of the same species.

Dobbins and coworkers (*1*) and Mitchell, Hamilton, and Beadles (*8*) studied the biological value of the protein of strains of corn, which vary with respect to total protein content, and found that the protein of the high-protein variety was of a lower biological value than that of the low-protein corn. Mitchell concluded that the lower biological value of the high protein variety resulted from a proportional increase in the percentage of the total protein which was zein, the alcohol-soluble protein of corn. Sauberlich (*10, 11*), Frey (*2*), and Schneider (*12*) concluded that zein accounted for an increasing percentage of the total protein as the protein level in the corn increased. An increase in the total protein of corn induced by fertilization resulted in an impairment of the growth-promoting value of the protein (*11*).

Jones, Caldwell, and Widness (*7*) clearly demonstrated that oat protein will support a more rapid rate of growth in rats than the protein of other grains tested (rye, corn, wheat, and barley). However, no information was available on the growth-promoting value of the protein of different oat varieties. Frey (*4*) found differences in the ratios of the essential amino acids among 14 varieties of oats. Frey (*3*) also found that the alcohol-soluble fraction of the protein of oats remained a constant percentage of the total protein in oats containing different levels of protein. Apparently, oats do not resemble corn in this respect.

Should substantial differences exist in the nutritional value of the protein of different varieties of oats, this fact should be considered in the selection of oat varieties for introduction. In the absence of adequate information concerning variety differences, studies were undertaken to evaluate the growth-promoting value of the proteins of representative varieties of oats.

Methods

The oat samples used in these studies were grown on separate plots on the agronomy farm at Perkins, Okla., unless otherwise stated. Harvesting and threshing were carried out so as to avoid mixing of the varieties. The whole oats were ground in a Wiley mill before being incorporated into the diets. The same samples of oats, harvested in 1952, were used in experiments 1 and 2. The samples used in experiment 3 were harvested in 1953, and those used in experiment 4 were harvested in 1951.

Female albino rats of the Sprague-Dawley strain, weighing from 40 to 60 grams, were used. They were divided into similar groups by weight and were housed in individual cages with raised screen bottoms. Water was provided *ad libitum*, and each animal was offered 20 grams of diet on the first, third, and fifth days of each week, and 10 grams on the seventh day. The food remaining was collected and weighed at weekly intervals; however, little food was left uneaten.

Each diet contained:

	G./100 G.	Mg./100 G.
MAJOR CONSTITUENTS		
Salts 4 (*5*)	2	
Corn oil	2	
Choline chloride	0.1	
MIXTURE OF VITAMINS		
Thiamine		0.4
Riboflavin		0.6
Pyridoxine hydrochloride		0.3
Nicotinic acid		2.0
Calcium pantothenate		2.0
Inositol		2.0
p-Aminobenzoic acid		2.0
Folic acid		0.05

The diets were stored under refrigeration. Two drops of cod liver oil fortified with α-tocopherol were added at each feeding. The levels of crude protein and crude fiber in the oat samples were determined by the procedures of the Association of Official Agricultural Chemists. The levels of crude protein in the diets were adjusted to the same value within experiments by varying the levels of the protein sources in the diets. The crude-fiber content of each diet was adjusted to similar levels within experiments by adding cellulose. The diets were made to 100% by the addition of cornstarch.

The microbiological assays for lysine and methionine were carried out by the method of Henderson and Snell (*6*). *Leuconostoc mesenteroides* was the assay organism employed.

Results

Table I, which includes the results from four experiments, shows the weight gains of the groups fed different oat varieties. In experiments 1 and 2, nine winter varieties and seven spring varieties are compared. In these two experiments, the same samples of oats were used; in experiments 3 and 4, samples from plantings of other years were used. In experiment 3, only nine winter varieties were compared and in experiment 4, six winter varieties and one spring variety were compared. A group of rats that received casein as the sole protein source and a group that received wheat were included in each experiment.

As the growth rates of the groups receiving similar protein sources in different experiments are not consistent, it is important to make direct comparisons only within experiments, and only of the relative rank of the weight gained among those groups in the same experiment.

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For the total food consumptions of the animals, the variations were slight and did not parallel the differences in growth rate because food intake was restricted. The ranges in the mean food consumptions for the groups in each experiment are as follows: experiment 1, 372 to 407 grams; experiment 2, 394 to 410 grams; experiment 3, 382 to 418 grams; and experiment 4, 368 to 403 grams.

The mean weight gain of all the animals receiving winter varieties was slightly greater than the mean weight gain of the animals receiving spring varieties in experiments 1 and 2 (experiment 1, winter varieties, 54.5 grams, spring varieties, 52.7 grams; experiment 2, winter varieties, 59.0 grams, spring varieties, 57.1 grams). However, these differences were not statistically significant.

Cimarron, a winter variety, caused very good weight gains in the three experiments in which it was tested. In experiments 1 and 3, the groups which received Cimarron showed the greatest gains of the groups fed oats. In experiment 2, the gain of the group which received Cimarron was exceeded only by that of the group which received Kanota, a spring variety.

As Cimarron was one of the best varieties, the weight gains of the groups which received the other varieties have been compared to that of the group which received Cimarron. In experiment 1, statistically significant differences were found between the gain of the group fed Cimarron and those of the groups fed Woodward Composite Selection (4829) ($P < 0.01$), Andrew ($P < 0.01$), and Cherokee ($P < 0.05$). The only gains in experiment 2 found to be significantly less than that of the group fed Cimarron were those of the groups fed Andrew ($P < 0.01$) and Clinton ($P < 0.05$). The gains of the groups fed Woodward Composite Selection (4827), DeSoto, Stanton Strain 1, and Tennex, in experiment 3, differed from the gain of the group fed Cimarron by an amount which was statistically highly significant ($P < 0.01$).

In experiment 4, the gain of the group fed DeSoto was significantly less ($P < 0.01$) than the gains of any of the other groups in that experiment which received oats. These were the only statistically significant differences among the groups receiving oats in this experiment.

In each experiment presented in Table I, the groups fed casein gained more weight than any group fed oats. The groups fed wheat in each experiment gained less weight than any group fed oats.

Microbiological assays for lysine and methionine were carried out on the oat samples fed in experiment 3 (Table II). The levels of the amino acids have been expressed per 16 grams of nitrogen. As iso-nitrogenous diets were used, direct comparison can be made between these values. Although there were some variations in these two amino acids among the samples tested, there was no correlation between the growth rates observed in experiment 3 (Table I) and the levels of either of these amino acids in the oats.

Table III gives the results of experiments on the effect of date and location of planting on the growth-promoting value of oat proteins. Samples of the Neosho and Andrew varieties were planted on March 1 and similar samples on March 20, 1951. When the grains from these plantings were fed to rats, there were differences in the weight

Table I. Growth of Rats Fed Different Oat Varieties in Four Experiments[a]

Oat Variety	Type	Grams Gain per 6 Weeks[b] 1	2	3	4
Woodward Composite Selection (4829)	Winter	45.2 ± 3.5[c]	57.8 ± 1.8	65.0 ± 1.7[c]	
DeSoto	Winter	51.6 ± 3.9	57.3 ± 1.9	65.2 ± 2.2[c]	33.9 ± 1.5
Stanton Strain 1	Winter	55.2 ± 2.6	61.0 ± 1.9	65.2 ± 2.6[c]	53.5 ± 2.3
Tennex	Winter	57.8 ± 3.0	57.0 ± 2.3	64.4 ± 2.5[c]	55.5 ± 2.9
Traveler	Winter	56.2 ± 4.7	58.7 ± 2.3	71.9 ± 2.0	55.6 ± 2.4
Wintok	Winter	54.8 ± 3.4	57.0 ± 2.6	76.7 ± 1.4	56.1 ± 2.3
Winter Fulghum selection (6570)	Winter	56.6 ± 4.0	61.2 ± 1.6	73.0 ± 1.3	
Forkedeer	Winter		60.2 ± 0.8	75.0 ± 2.3	58.1 ± 2.8
Cimarron	Winter	58.2 ± 1.6	60.7 ± 2.2	77.7 ± 3.2	
Andrew	Spring	48.4 ± 3.7[c]	52.0 ± 3.0[c]		53.9 ± 2.1
Neosho	Spring	50.2 ± 4.2	59.2 ± 1.6		
Cherokee	Spring	49.8 ± 3.3[d]	57.8 ± 1.4		
Clinton	Spring	54.8 ± 2.2	54.0 ± 0.9[d]		
Kanota	Spring	53.4 ± 4.4	64.5 ± 1.0		
Nemaha	Spring	56.7 ± 0.7	56.5 ± 2.5		
0-200	Spring	55.6 ± 0.9	56.0 ± 2.0		
Casein		61.4 ± 5.1	68.7 ± 4.3	87.9 ± 3.1	73.9 ± 2.6
Wheat		35.4 ± 4.6	37.8 ± 2.8	59.4 ± 1.1	33.4 ± 1.7

[a] Diets contained: experiments 1 and 2, 9.4% of crude protein; experiment 3, 9.5%; and experiment 4, 10.6%.
[b] Mean ± standard error of mean for: five rats in experiment 1; six rats in experiment 2; and 10 rats for experiments 3 and 4.
[c] Difference between this group and that for group receiving Cimarron oats was statistically highly significant ($P < 0.01$).
[d] Difference between this value and that for group receiving Cimarron oats was statistically significant ($P < 0.05$).

Table II. Levels of Lysine and Methionine in Oat Samples Used in Experiment 3, Table I

Variety	L-Lysine[a]	L-Methionine[b]
Woodward Composite Selection (4829)	4.06 ± 0.15	1.49 ± 0.03
DeSoto	4.22 ± 0.19	1.60 ± 0.05
Stanton Strain 1	3.85 ± 0.19	1.23 ± 0.05
Tennex	3.92 ± 0.19	1.12 ± 0.04
Traveler	4.10 ± 0.14	1.24 ± 0.07
Wintok	4.40 ± 0.08	1.60 ± 0.01
Winter Fulghum Selection (6570)	3.78 ± 0.20	1.32 ± 0.04
Forkedeer	3.81 ± 0.11	1.30 ± 0.03
Cimarron	4.25 ± 0.18	1.59 ± 0.05

[a] Grams of lysine per 16 grams of nitrogen, mean ± standard error of mean for eight values.
[b] Grams of methionine per 16 grams of nitrogen, mean ± standard error of mean for five values.

Table III. Effect of Location and Date of Planting on Growth Promoting Value of Oats

Experiment[a]	Group	Variety	Date of Planting	Location	Gram Gain/6 Weeks
1	1	Neosho	March 1, 1951	Perkins	52.5 ± 2.1[b]
	2	Neosho	March 20, 1951	Perkins	51.8 ± 1.7
	3	Andrew	March 1, 1951	Perkins	56.9 ± 1.8
	4	Andrew	March 20, 1951	Perkins	57.3 ± 3.1
	5	Forkedeer	Sept. 21, 1952	Perkins	59.0 ± 1.6
	6	Forkedeer	Sept. 21, 1952	Lake Blackwell	57.0 ± 2.2
2	7	Cimarron	March 1952	Perkins	59.0 ± 2.2
	8	Cimarron	Sept. 1952	Perkins	58.2 ± 1.6
3	9	Cimarron	March 1952	Perkins	60.7 ± 2.2
	10	Cimarron	Sept. 1952	Perkins	61.8 ± 1.5

[a] Diets contained 10.0% crude protein in experiment 1 and 9.4% of crude protein in experiments 2 and 3.
[b] Mean ± standard error of mean for a group of 10 rats in experiment 1 (groups 1 to 6), five rats in experiment 2 (groups 7 and 8), and six rats in experiment 3 (groups 9 and 10).

gains between the groups receiving different varieties but no significant differences between the gains of the groups fed the same variety from different dates of planting. To test the effect of location of planting, Forkedeer oats were planted at the same date but one sample was planted at Perkins, Okla., on Vanoss loam and the other at Lake Carl Blackwell, Okla., on a combination of Port loam and Port clay loam. Similar yields were obtained at both locations. There was no significant difference between the weight gains of the groups which were fed these samples.

In the other two experiments presented in Table III, the nutritive values of two samples of Cimarron oats are compared. One sample was planted in September, the usual time in this area for planting this winter variety, and the other sample was planted in March, which is the usual date for planting spring oats. No significant differences in weight gains were found.

Discussion

Substantial differences in the growth-promoting values existed among the 16 varieties of oats subjected to evaluation in these studies. As the diets contained adequate quantities of required nutrients other than protein, these differences are attributed to differences in the protein of the samples. These differences are apparently characteristic of the varieties, for the samples were grown under conditions as similar as possible, and the findings were in general similar to samples from different plantings.

Samples of oats planted at different dates or locations caused similar weight gains in rats. Although this was not an extensive study, it suggests that these environmental factors are of lesser importance in determining the nutritive value of oat protein than are those of genetic origin.

Cimarron, Forkedeer, and Winter Fulghum Selection (6570), three winter varieties, consistently produced good growth results when fed to rats. There is no indication that the nutritive values of these varieties are significantly better than those of most other winter varieties. However, two winter varieties, Woodward Composite Selection (4829) and DeSoto, consistently caused poor growth results. It is possible that the differences would be of importance when oats were to be used in feeds for nonruminant farm animals and poultry.

There was a trend toward less weight gain in the groups fed the spring varieties of oats than in the groups fed winter varieties. The spring varieties were studied in only two experiments and the same samples of oats were used in both experiments—not a satisfactory test to determine nutritive value. However, one spring variety, Andrew, caused poor rates of growth in three experiments and probably is not as good a protein source as the better winter varieties.

As protein is the limiting factor in these diets, the differences in the growth rates suggest that the poorer oat varieties supply less of one or more of the essential amino acids to the rats. Mitchell and Smuts (*9*) found that lysine was the most limiting amino acid in oats for the growth of rats. Unpublished data from the author's laboratory indicate that methionine and threonine are the next most limiting amino acids in oats. Microbiological assay for lysine and methionine showed that there was no correlation between the levels of these amino acids in the oat samples and the weight gains of groups that received them. If the differences between the varieties are not due to the levels of the growth-limiting amino acids, they may be due to differences in the availability of the essential amino acids to the rat.

It will be important to determine the cause of the differences in the nutritive values of the oat varieties. If these differences are the result of poor availability of a single amino acid, the importance of these results will depend on what other sources of protein will be fed with the oats. If all of the amino acids of the poor oat varieties are less available to the animal, it will be an important consideration whenever oats are used as a protein source for nonruminants.

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SELENIUM POISONING

Modification of Selenite Metabolism by Arsenite

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THE FEEDING of various arsenic compounds has shown considerable promise as a means for the control of selenium poisoning in livestock. The protective action of arsenic has been demonstrated by feeding experiments with rats (*3*), hogs (*11*), and cattle (*10*). Organic arsenicals are about as effective as inorganic salts (*8*).

Little is known of the mechanism involved in the antagonism between selenium and arsenic, but a few facts have been ascertained by work with rats and yeast. Analyses of rats fed selenium and arsenic for several weeks revealed no differences in selenium distribution caused by administration of enough arsenic to prevent the appearance of symptoms of selenium posioning (*6*).

In yeast, the study of selenite inhibition of respiration has been broadened to include the effect of several ions and substrates (*2*). The inhibition is reduced by addition of arsenite, arsenate, or

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