Nutritive Value of Oat Protein. I. Varietal Differences as Measured by Amino Acid Analysis and Rat Growth Responses[1]

H. H. HISCHKE, Jr., G. C. POTTER, and **W. R. GRAHAM, Jr.,** The Quaker Oats Company, John Stuart Research Laboratory, Barrington, Ill.

ABSTRACT

Seven pure varieties of oats grown under similar environmental conditions at Grayslake, Ill., offered an opportunity for comparative studies on protein quality. Samples of oat groats ranging in protein content from 18.1 to 22.2% had highly significant differences in lysine, glutamic acid, and glycine content. The content of the other amino acids detected was uniform in all samples. Rat growth data did not reveal any significant differences in nutritive value of the varieties used.

A review of the literature pertaining to the nutritive quality of oat protein indicates the need for more nutritional data. Amino acid analysis and comparative feeding studies show that the oat is equal or superior in nutritional quality to the other commonly used cereal grains (1).

Reports by various workers have indicated that varietal and environmental conditions influence the amino acid composition of oat protein. Frey (2) demonstrated that a change in lysine, methionine, and tryptophan content accompanied a change in the total nitrogen level of oat samples. Differences in the lysine content of the varieties with varying protein content for any given year were very small. But from year to year as the protein content increased, the content of lysine, expressed as a percentage of the total protein, also increased. McElroy *et al.* (3) found that the lysine content of nine samples of oats ranging in protein content from 9.4 to 18.9% remained uniform. The samples were of one pure variety; thus variations in protein content reflected environmental influences.

Weber *et al.* (4) reported a significant difference in growth response when various oat varieties were fed at an isonitrogenous level to rats. The lysine content of the samples was similar and uncorrelated with growth rate.

MATERIALS AND METHODS

Seven pure varieties of oats grown during the 1964 crop year were obtained from a commercial seed dealer at Grayslake, Ill. The groats of the samples grown on the same farm under similar environmental conditions ranged from 18.1 to 22.2% in protein content.

Hydrolysates were prepared by mixing 50 mg. of finely ground groats and 2 ml. 6*N* hydrochloric acid in a Pyrex test tube. The samples were frozen, sealed under vacuum, and heated at 110°C. for 22 hr. Amino acids were determined by ion-exchange chromatography with a Spinco Model 120B amino acid analyzer (5). Each sample was hydrolyzed and analyzed in quadruplicate.

Twenty-one-day feeding trials were conducted with weanling white

[1] Contribution from The Quaker Oats Company, John Stuart Research Laboratory, Barrington, Ill. Authors, respectively, are: Project Leader and Group Leader, Scientific Advisory Division, and Director of Research.

rats weighing 40 to 50 g. The diets were formulated to 10% protein level. Corn oil was added to adjust all diets to 10% fat level. The composition of the seven diets is given in Table I.

TABLE I

COMPOSITION OF OAT DIETS FORMULATED TO A 10% PROTEIN CONTENT AND A 10% FAT CONTENT

	RATION NUMBER AND COMPOSITION[a]						
	1	2	3	4	5	6	7
SAMPLE	27.8 7.5	25.2 6.4	35.3 7.2	28.4 6.6	34.2 7.1	27.1 4.5	33.1 7.7
	%	%	%	%	%	%	%
Garland	56.5						
Clintland		60.2					
Bonkee			49.3				
Newton				56.8			
Beedee					50.5		
Lodi						60.2	
Nemaha							51.0
Premix[b]	8.2	8.2	8.2	8.2	8.2	8.2	8.2

[a] Upper figure, % corn starch; lower figure, % corn oil.
[b] Premix includes 4.0% salt mix, 2.2% vitamin mix, and 2.0% celluflour.

RESULTS

The protein content and amino acid composition of the seven oat varieties are given in Table II. Statistical analyses of the amino acid data indicated a significant difference between the mean values reported for lysine, glutamic acid, glycine, and alanine.

TABLE II

PROTEIN CONTENT AND AMINO ACID COMPOSITION OF SEVEN OAT VARIETIES

	GARLAND	CLINTLAND	BONKEE	NEWTON	BEEDEE	LODI	NEMAHA
	%	%	%	%	%	%	%
Protein[a]	19.40	18.20	22.20	19.20	21.60	18.10	21.40
Lysine[b]	3.72	3.77	3.55	3.59	3.56	3.69	3.55
Histidine	2.25	2.23	2.23	2.23	2.18	2.18	2.18
Ammonia	2.55	2.68	2.76	2.65	2.62	2.58	2.53
Arginine	6.73	6.83	6.62	6.58	6.61	6.54	6.58
Aspartic acid	8.58	8.14	8.38	8.12	8.91	8.43	8.43
Threonine	3.49	3.45	3.41	3.40	3.49	3.51	3.40
Serine	4.94	4.87	4.88	5.06	4.86	5.01	4.92
Glutamic acid	23.65	23.39	24.30	24.09	24.26	23.48	24.28
Proline	5.33	5.44	5.48	5.51	5.34	5.63	5.41
Glycine	5.03	4.90	4.81	4.98	4.83	5.19	4.93
Alanine	4.83	4.78	4.59	4.79	4.66	4.73	4.71
Half-cystine	1.03	1.41	1.42	1.36	1.38	1.75	1.24
Valine	5.48	5.60	5.29	5.40	5.36	5.23	5.47
Methionine	1.51	1.60	1.44	1.43	1.13	1.42	1.56
Isoleucine	4.07	4.09	4.02	4.00	4.02	3.88	4.02
Leucine	7.85	7.87	7.83	7.92	7.79	7.78	7.84
Tyrosine	3.34	3.24	3.42	3.21	3.48	3.45	3.53
Phenylalanine	5.55	5.61	5.50	5.57	5.52	5.49	5.59

[a] Protein values are expressed on moisture-free basis.

[b] Amino acids are expressed as percentage of total amino acids plus ammonia recovered. Each value is average of four replicates.

Regression lines were fitted to the data of the four amino acids which displayed significant differences (Figs. 1 to 4). Correlations between the protein content and lysine, glutamic acid, and glycine levels were significant. The lysine and glycine level of the samples decreased on the basis of percent of total protein as protein content increased. The level of glutamic acid was directly correlated to sample protein content.

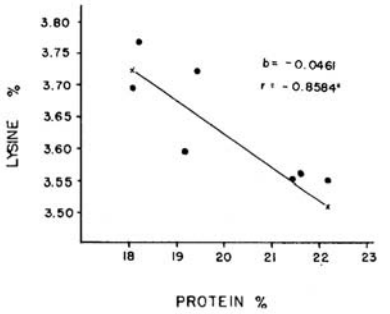

Fig. 1. Relation between lysine and protein content of seven varieties of oats. Lysine is expressed as percentage of total amino acids plus ammonia recovered. This applies also to the amino acids in Figs. 2, 3, and 4.

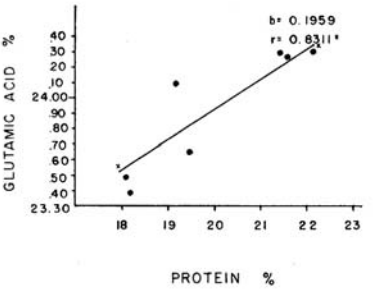

Fig. 2. Relation between glutamic acid and protein content of seven varieties of oats.

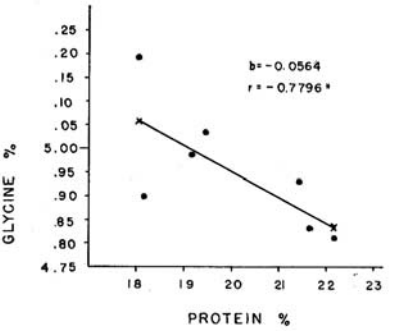

Fig. 3. Relation between the glycine and protein content of seven varieties of oats.

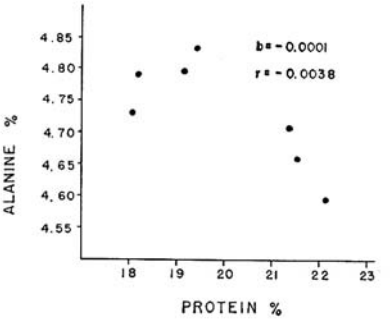

Fig. 4. Relation between the alanine and protein content of seven varieties of oats.

The 21-day weight gains, feed intake, and protein efficiency ratios (PER's) obtained from the feeding trials are shown in Table III. Each

TABLE III
TWENTY-ONE-DAY FEEDING DATA[a]

	GARLAND	CLINTLAND	BONKEE	NEWTON	BEEDEE	LODI	NEMAHA
Weight gain, g.	46.5	48.6	42.9	42.9	44.3	43.1	43.1
Feed intake, g.	194.6	203.9	188.0	190.3	194.1	189.9	188.9
PER[b]	2.37	2.38	2.28	2.25	2.27	2.25	2.28

[a] Each value is an average of 10 rats.
[b] PER is g. gain in body weight per g. of protein intake.

value is an average of 10 rats. Although the highest PER values were obtained from the diets of Clintland and Garland oat varieties which had lysine contents of 3.77 and 3.72% respectively, individual animal variation was too large to detect significant differences in the PER values.

DISCUSSION

The uniformity of amino acid composition between the seven varieties of oats investigated is evident from the analytical data. The highly significant statistical difference detected for lysine, glycine, and glutamic acid suggests that protein content may be correlated with certain essential and nonessential amino acids. The negative relation of lysine to protein content is typical of other cereal grains, although to a lesser degree.

Waggle *et al.* (6), working with sorghum grain, reported that a 33.1% increase in protein resulted in a 27% decrease in lysine. Sauberlich *et al.* (7) found a 20% decrease in lysine corresponding to a 33.3% increase in protein content. These changes were much larger than those in the oat samples. The lysine content decreased only 5.8% as protein content increased 18.5%.

The lack of pronounced response between lysine level and protein content as displayed by sorghum grain and corn may be a reflection of the basic protein constituents of oats. The alcohol-soluble protein of corn and of oats is low in lysine (8). Zein comprises 28 to 60% of the corn protein (9) and is directly proportional to the protein content (10). The prolamine content of oat protein, however, is approximately 16% (11) and, according

to Frey (12), remains a constant proportion of the total protein regardless of the protein content.

The feeding data obtained from the seven oat varieties indicated that any differences in amino acid levels were too small to influence growth responses. Since lysine is the first-limiting amino acid of oat protein, any large differences in lysine should be reflected in growth response. The existence of significant lysine differences and nonsignificant PER values reflects the high accuracy of the analytical methods employed and indicates that small varietal variations may not be of prime importance from a practical standpoint.

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