# Protein Quality and Metabolizable Energy Value of Pigeon Grass Screenings

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A by-product of the small grains industry, pigeon grass screenings (PGS), was evaluated as a feedstuff for monogastric animals. The PGS evaluated was composed primarily of yellow foxtail (Setaria viridis L.) and green foxtail (Setaria lutescens) seeds. Growth studies with weanling rats showed that the quality of protein in PGS was relatively poor. Commercial strain broiler chicks were used to determine the metabolizable energy (ME) value of PGS. An experiment with White Leghorn laying hens illustrated that PGS was a satisfactory feedstuff for egg production. The fatty acid composition of PGS was reflected by some changes in the fatty acid distribution in egg yolk fat (i.e., an increase in linoleic acid and a decrease in oleic acid). However, these changes were not of large magnitude nor were they deemed of practical importance.

The increase in prices of major feed grains in the United States since 1973 has stimulated a search for alternative sources of dietary energy for farm animals.

In some regions, particular attention has been directed toward assessing the usefulness of certain weed seeds that are obtained annually from the cleaning of grains such as wheat, barley and flax. The product of the cleaning process, termed "screenings" or "ground grain by-products," normally contains a variety of weed seeds including wild buckwheat (**Polygonum convolvulus L.**), and yellow and green foxtail (**Setaria viridis L.** and **Setaria lutescens**, respectively). Samples of screenings obtained in the Minnesota, North Dakota, South Dakota and Montana region in recent years have been comprised primarily of green and yellow foxtail, popularly and compositely called pigeon grass.

The amounts of pigeon grass screenings produced each year is not known precisely. But, based on the meager information available, it appears that the total amount would exceed two billion pounds in the north central United States annually, and certainly the quantity on a worldwide basis would be massive. Potentially, these two billion pounds could replace nearly an equal quantity of corn, barley or other feed grains in animal feeds, thereby releasing these grains for other uses.

Little information is available in the literature describing the nutritional attributes of screenings, especially screenings mainly composed of pigeon grass seeds. Harrold and Nalewaja (1977) have compiled proximate analysis and amino acid data on several weed seeds including pigeon grass. Recently, Harrold **et al** (1975) showed that pigeon grass seed could be used successfully to replace barley in rations for growing swine up to at least 40 per cent of the ration. Dinusson **et al** (1975) found that growing cattle fed pigeon grass seed at 30 per cent of the ration gained more slowly and much less efficiently than cattle fed barley. The authors are not aware of additional information of recent vintage.

**Table 1. The seeds and extraneous materials present in pigeon grass seed screenings.**

| Component | % of total weight |
|---|---|
| Yellow and Green pigeon grass seed | 67.96 |
| Cracked wheat | 16.03 |
| Red-root pigweed | 3.67 |
| Millet | 2.54 |
| Wild buckwheat | 1.05 |
| Miscellaneous seeds (mustard, flax, smartweed, etc.) | 5.66 |
| Chaff and dirt | 3.09 |

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The research reported here was conducted to obtain more detailed information about the feeding value of pigeon grass seed screenings, with special emphasis on the usefulness for monogastric animals.

A series of experiments was conducted using rats, chicks and laying hens as test animals. The pigeon grass seed screenings (PGS) evaluated were from a single batch and were composed of the seeds and materials listed in Table 1. Shown in Table 2 are the dry matter, acid-detergent fiber, ether extract, protein, selected amino acid concentrations and fatty acid distribution of the PGS as determined by laboratory analyses.

**Table 2. The chemical composition of pigeon grass seed screenings.**

| Constitute | % on an "as is" basis |
|---|---|
| Dry matter | 88.1 |
| Protein | 14.3 |
| Fiber | 20.0 |
| Ether extract | 5.6 |
| Amino acids | |
| Lysine | 0.36 |
| Methionine | 0.38 |
| Arginine | 0.58 |
| Threonine | 0.56 |
| Valine | 0.76 |
| Isoleucine | 0.62 |
| Leucine | 1.68 |
| Phenylalanine | 0.77 |
| Histidine | 0.51 |
| | % of total methyl esters in the ether extract |
| Fatty acids | |
| Palmitic ($C_{16}$) | 15.2 |
| Oleic ($C_{18:1}$) | 24.3 |
| Linoleic ($C_{18:2}$) | 54.5 |
| Linoleic ($C_{18:3}$) | 4.8 |
| Unidentified $C_{20}$ or $C_{22}$ | 1.2 |

**Experiment 1**

Experiment 1 was conducted to assess the protein quality of PGS. For this purpose, 54 weanling rats, 25 days of age, were placed in wire cages, three rats per cage. Each cage was equipped with a waterer and a feeder. The rats were offspring of a cross between a Sprague-Dawley strain and a "Cream Hood" strain from the University of Oklahoma Medical Center. The rats were allotted to 18 groups of three each on the basis of body weight so that initial variation among the groups was minimized.

Semipurified diets, balanced in all nutrients except protein, were used. In one series of rations, all the protein was supplied by PGS (Table 3). A second series of rations contained lactalbumin as the protein source. Each series of rations was formulated so that three protein levels (12.3, 13.5 and 15.0 per cent) were obtained. Appropriate adjustments were made in the formulation so that the ratios of protein to digestible energy of the rations were approximately the same. The digestible energy data on similar PGS, as determined by Harrold **et al** (1975), were used to assess ration energy levels.

**Table 3. Composition of rations based on pigeon grass seed screenings without amino acid supplementation — Experiment 1.**

| Ingredient | | (% of the ration) | |
|---|---|---|---|
| Pigeon Grass seed | 70.0 | 80.0 | 90.0 |
| Corn oil | 4.3 | 5.6 | 6.0 |
| Corn starch | 1.0 | 1.0 | 1.0 |
| Alpha-cellulose | 21.7 | 10.4 | — |
| Vitamin Pre-mix | 1.0 | 1.0 | 1.0 |
| Mineral Pre-mix | 2.0 | 2.0 | 2.0 |
| **Calculated analysis** | | | |
| Protein, % | 12.3 | 13.5 | 15.0 |
| Lysine, % | 0.252 | 0.288 | 0.324 |
| Methionine, % | 0.266 | 0.304 | 0.342 |

On the basis of amino acid analyses, the protein of PGS appeared to be most limiting in lysine, and was marginal in methionine. Therefore, each PGS ration was fed without and with lysine and/or methionine supplementation. The levels of lysine and methionine supplementation were chosen so that the ration levels of these amino acids would fulfill the requirements of the growing rat. The levels of supplementation varied with protein concentration of the rations, ranging from 0.58 to 0.65 and 0.26 to 0.33 for lysine and methionine, respectively.

The influence of supplementing PGS rations with a non-specific amino nitrogen source was also determined. For this purpose, the nonessential amino acid, glycine, was included in one set of PGS rations. The levels of inclusion were equivalent, on a nitrogen basis, to the levels of lysine and methionine supplementation used in another set of ration treatments. This set of rations formed a positive control series. In total, the PGS with and without amino acid series comprised 15 ration treatments. The rations containing three levels of lactalbumin as the protein source comprised the final three ration treatments.

The rations were fed to the rats **ad libitum** for 21 days. Individual body weights and group feed consumption data were recorded weekly.

The results show that rations based on PGS with no amino acid supplementation supported very poor rat growth and a low protein efficiency ratio (PER) regardless of dietary protein level (Table 4). Supplementation of the PGS rations with methionine or glycine failed to improve rat performance. In contrast, the inclusion of lysine markedly increased weight gains and PER of rats fed PGS. It is noteworthy that methionine was also an ineffective supplement when additional lysine was used, suggesting that methionine was not the second most limiting amino acid in PGS protein although the amino acid analysis data indicated that it was.

**Table 4. Average gain in weight and protein efficiency ratios of rats fed pigeon grass seed screenings — Experiment 1.**

| | Protein level, % | | | |
|---|---|---|---|---|
| Ration treatment | 12.3 | 13.5 | 15.0 | Avg. |
| | (Average 21 day gain per rat, g) | | | |
| Pigeon Grass seed screenings (PGS) | 25 | 26 | 25 | 26 |
| PGS + lysine (L) | 103 | 113 | 134 | 117 |
| PGS + methionine (M) | 24 | 29 | 24 | 26 |
| PGS + L + M | 102 | 106 | 121 | 110 |
| PGS + glycine | 23 | 21 | 32 | 25 |
| Lactalbumin | 83 | 96 | 116 | 98 |
| Average | 60 | 65 | 75 | |
| | (g gain/g protein consumed—PER) | | | |
| PGS | 0.74 | 0.86 | 0.80 | 0.80 |
| PGS + L | 2.00 | 1.95 | 1.86 | 1.94 |
| PGS + M | 0.89 | 1.02 | 0.74 | 0.88 |
| PGS + L + M | 1.87 | 2.06 | 1.83 | 1.92 |
| PGS + glycine | 0.76 | 0.65 | 0.82 | 0.74 |
| Lactalbumin | 2.28 | 2.03 | 2.10 | 2.14 |
| Average | 1.42 | 1.43 | 1.36 | |

PGS rations which contained supplemental lysine compared favorably with rations in which the protein was supplied by lactalbumin. Lactalbumin appeared to be slightly superior in terms of PER, even though PGS plus lysine supported slightly higher weight gains.

In general, these data illustrate clearly that the protein quality of PGS is poor. On the basis of PER, it is only 37 per cent of the value of lactalbumin. However, adequate supplementation of PGS protein with the most limiting amino acid, lysine, increased its relative PER to 91 per cent of that of lactalbumin. Thus, it appears that PGS can be utilized efficiently as a major component of rations for monogastrics, provided that careful consideration is given to lysine adequacy of the rations.

**Experiment 2**

The objective of the experiment was to determine the metabolizable energy value of PGS. Ten 7-day-old chicks were alloted to each of nine pens located in an electrically heated brooder battery. The chicks were supplied with feed and water **ad libitum**, and five days were allowed for the chicks to adjust to the assigned ration treatment.

Three ration treatments were used. A reference diet served as one treatment and was composed of the following, listed as a per cent of the ration: sucrose, 50; soybean meal (44 per cent protein), 23.4; casein, 10.5; meat and bone meal (50 per cent protein), 2.0; dehydrated alfalfa meal (17 per cent protein), 1.0; dried fish solubles (32 per cent protein), 2.0; dicalcium phosphate, 2.5; ground limestone, 2.4; mineral premix, 0.3; vitamin premix, 0.8; animal tallow, 4.0; DL-methionine, 0.1 and chromic oxide premix (30 per cent chromic oxide), 1.0. The reference diet was adequate in all nutrients known to be essential for the chick. Additional ration treatments were formed by substituting PGS for one-half or all of the sucrose of the reference diet. Thus, PGS comprised 25 per cent or 50 per cent of the rations. Chromic oxide was included in all rations to serve as an index substance for ME determination.

Following the adjustment period, excreta samples were collected for five consecutive days from each pen. The excrement was dried in an air convection oven. Samples of excreta and rations were analyzed for nitrogen by the macro-kjeldahl procedure, for heat of combustion using a Parr adiabatic bomb calorimeter, and for chromic oxide by the method of Bolin and Lockhart (1960). Classical and nitrogen-corrected ME values for PGS were calculated according to the procedures of Hill and Anderson (1958). An ME value of 3720 kilocalories per kg for sucrose was used in the ME calculations.

The metabolizable energy (ME) value of PGS for chicks varied slightly, dependent upon the level of inclusion in the ration (Table 5). When PGS comprised 25 per cent of the ration, an ME value of 2990 kcal/kg dry matter was obtained. A lower value, 2780 kcal/kg, was observed when

**Table 5. The metabolizable energy value of pigeon grass seed screenings for chicks — Experiment 2.**

| Level of pigeon grass seed screenings in ration | Metabolizable energy value kcal/kg dry matter |
|---|---|
| 25% | 2990 ± 141[1] |
| 50% | 2780 ± 120 |

[1] *Mean of three determinations ± standard error.*

PGS was used at 50 per cent of the ration. The reason for this discrepancy is not known. However, the possibility exists that as the proportion of PGS in the ration increased, a slight interference with overall digestibility and nutrient utilization occurred. Consequently, ME was lowered somewhat. Under practical circumstances, the lower ME value (2780 kcal/kg) seems more appliable since relatively high levels of PGS are used frequently.

The ME values obtained in this study are similar to the one reported by Sell and Johnson (1969). Using turkey poults, they found that a sample of screenings composed almost entirely of pigeon grass had an ME of 2880 kcal per kg dry matter. The ME value of PGS as determined here also compares favorably with that of barley (2950 kcal/kg dry matter). Research with rats also indicated that the digestible energy (DE) value of PGS for rats was comparable to barley (Harrold **et al.** 1975).

**Experiment 3**

This experiment was conducted to determine the influence of the fatty acid content of PGS on the fatty acid composition of egg yolk and adipose tissue of chickens. Twenty-seven, 32-week-old White Leghorn hens of a commercial strain were placed in individual wire cages. The hens had been fed a ration based on corn and soybean meal. Subsequently, each of three ration treatments was assigned to nine hens. One treatment was a low-fat, semipurified diet which consisted of the following, given as a per cent of the ration: sucrose, 65; isolated soy protein, 15; ground limestone, 6.0; dicalcium phosphate, 2.0; vitamin premix, 0.25; mineral premix, 0.30 and DL-methionine, 0.10. This ration contained less than 0.2 per cent fat. Two additional ration treatments were obtained by substituting PGS, on an isonitrogenous basis, for sucrose and soy protein so that PGS comprised either 40 per cent or 80 per cent of the ration. Thus, PGS contributed 2.24 per cent and 4.48 per cent fat to the 40 per cent and 80 per cent rations, respectively. The ration treatments and water were provided to the hens **ad libitum** for 21 days.

Immediately before starting the experiments, eggs were collected from the hens and adipose tissue was taken by biopsy to serve as pre-experimental samples for fatty acid determination. Eggs representing each treatment group were collected at the end of each week of the experiment. Adipose tissue was taken from three hens per treatment group at the end of three weeks experimentation.

In preparation for fatty acid analysis, the egg yolks were separated from the whites and were freeze-dried. Samples of dried yolk and adipose tissue were subjected to methyl esterification using a modification of the method of Metcalfe **et al.** (1961) as outlined by Sell **et al.** (1968). Similarly, methyl esters of the fatty acids of ether-extractable material of PGS were also obtained. The methyl esterified fatty acids were separated qualitatively by gas-liquid chromatography utilizing columns which contained 5 per cent diethyl glycol succinate on 80/100 mesh chromosorb WAW and a Beckman Model 65 chromatograph.

Feeding rations which contained 40 per cent or 80 per cent PGS to laying hens altered the fatty acid distribution in eggs and tissues, thereby indicating that the fat of PGS was digested and absorbed (Table 6). The most notable changes occurred in fatty acids of egg yolk fat and the pattern change was detectable by the end of week 2 of the trial. However, since the changes were largest at week 3, only data for this time are given. In comparison with the fat of eggs produced by hens fed the low-fat reference diet, egg fat of hens fed PGS contained considerably more linoleic acid ($C_{18:2}$) and less oleic acid ($C_{18:1}$). This appeared to be a direct reflection of the fatty acid composition of the ether extract of PGS. It is interesting to note that egg yolk fat of hens fed 80 per cent PGS was even higher in $C_{18:2}$ than that of hens fed the

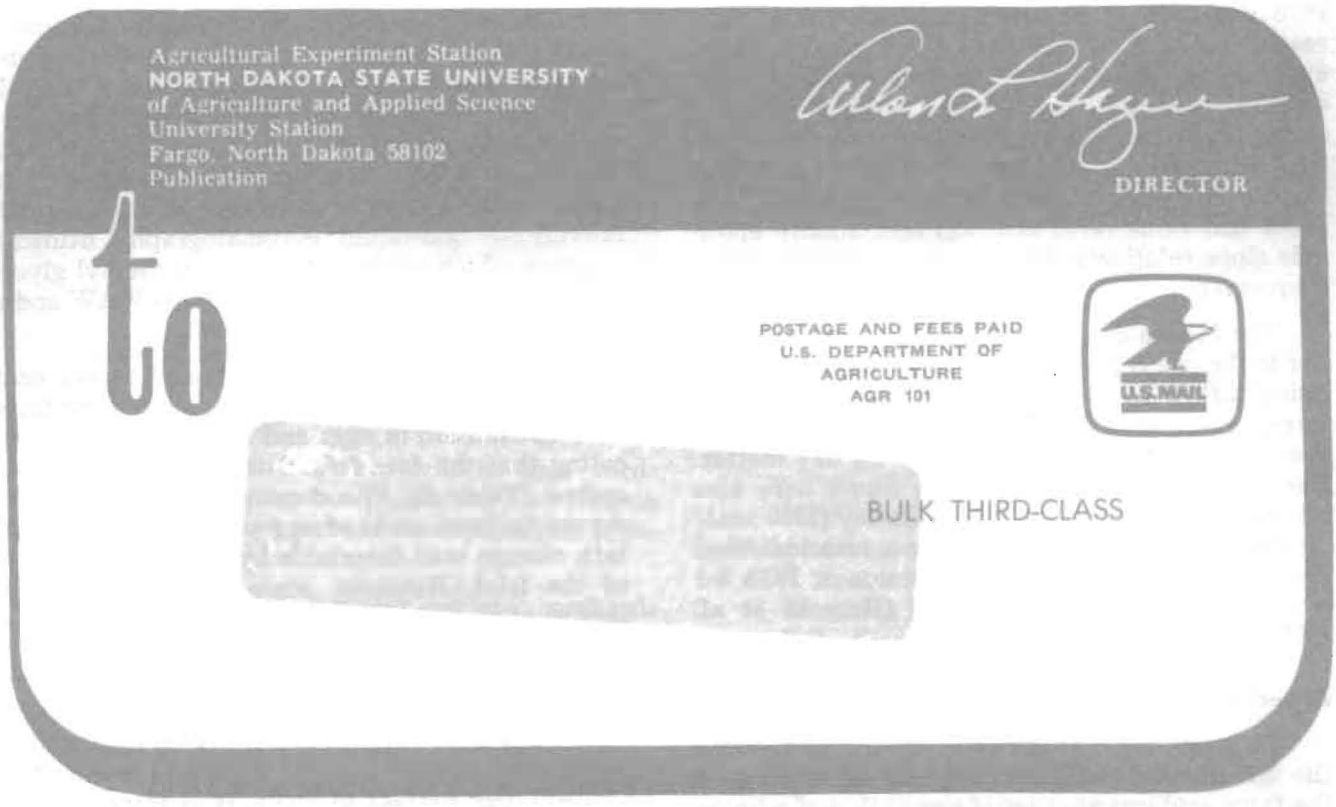
**Table 6. The influence of fatty acid composition of pigeon grass seed screenings on fatty acid distribution in egg yolk fat and adipose tissue of hens — Experiment 3.**

| Ration treatment | $C_{14:0}$[1] | $C_{16:0}$ | $C_{16:1}$ | $C_{18:1}$[2] | $C_{18:2}$ | $C_{18:3}$ |
|---|---|---|---|---|---|---|
| | (% of total methyl esters) | | | | | |
| **Egg yolk fat** | | | | | | |
| Pre-experimental | 0.9 | 38.1 | 4.8 | 41.9 | 14.1 | 0.2 |
| Low-fat diet | 1.1 | 38.0 | 6.4 | 51.3 | 3.4 | n.d. |
| 40% PGS[3] | 0.9 | 37.8 | 5.2 | 41.9 | 12.3 | 0.4 |
| 80% PGS[3] | 0.7 | 36.4 | 4.1 | 36.4 | 21.7 | 0.3 |
| **Adipose tissue** | | | | | | |
| Pre-experimental | 1.2 | 28.9 | 8.4 | 42.2 | 18.9 | 0.4 |
| Low-fat diet | 1.2 | 27.4 | 8.1 | 42.3 | 20.3 | 0.7 |
| 40% PGS[3] | 1.3 | 30.1 | 8.7 | 44.9 | 14.6 | 0.4 |
| 80% PGS[3] | 1.2 | 28.9 | 10.9 | 43.6 | 14.8 | 0.6 |

[1]*The numerical value before the colon indicates the number of carbons in the fatty acid and the second value shows the number of double bonds.*

[2]*The $C_{18:1}$ category also includes small amounts of $C_{18:0}$.*

[3]*The pigeon grass seed screenings contributed 2.24 and 4.48% ether extract to the diets for the 40 and 80% rations, respectively. The percentage fatty acid distribution of the PGS ether extract was $C_{16}$, 15.2; $C_{18:1}$, 24.3; $C_{18:2}$, 54.5; $C_{18:3}$, 4.8; and unidentified $C_{20}$ or $C_{22}$, 1.2.*




pre-experimental corn-based ration. This, too, illustrates the effect of dietary fatty acids on egg fatty acids. Corn contains only 1.9 per cent $C_{18:2}$ while the PGS used here contained 3.05 per cent $C_{18:2}$.

The influence of dietary fatty acids on egg yolk fatty acids observed here agrees well with findings of other researchers (Feigenbaum and Fisher, 1959; Machlin and Gordon, 1962; Sell **et al.** 1968; and Sim **et al**, 1973). However, very little effect of dietary PGS fatty acids on the fatty acid composition of adipose tissue was observed. An explanation for this apparent discrepancy may reside in the fact that change in the fatty acid composition of adipose tissue of a mature animal would be limited by the turnover rate of that tissue. In contrast, egg yolk fat would be derived from direct deposition of dietary fatty acids as well as from **denovo** fatty acid synthesis as it is formed. Also, hens usually contain a sizable amount of adipose tissue and it would probably require some time for a low level intake of dietary fatty acids to alter the fatty acid spectrum of adipose tissue noticeably.

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