A COMPARISON OF THE PERFORMANCE OF MEAT-STRAIN CHICKS FED PEARL MILLET OR SORGHUM GRAIN AS THE SOURCE OF ENERGY AND PROTEIN

by

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INTRODUCTION

It was hoped that pearl millet could effectively replace sorghum grain in the rations for broilers enabling the broiler industry to take advantage of any differences in pearl millet and sorghum grain prices and thus be able to compete for the expanding local markets.

Increased emphasis has been placed on growing cereal grains and considerable research has been done on quality and quantity of protein in major cereal grains (corn, rice, wheat, and sorghum grain) to accomplish this goal.

However, in the last decade millets have been getting substantial consideration not only for their nutritional value in human consumption, but for their different properties as a source of energy and amino acids in poultry rations.

In some parts of Africa, in India, and Pakistan, millet is grown on more than 40,000,000 acres of land primarily as a grain crop for human consumption, it is usually tolerant of drought and heat and produces grain in regions too hot and dry for other cereals. Burton (1972) and Oyenuga (1968) have observed that pearl millet is the best summer pasture grass for the sandy soils of the southeastern United States. Busson, as reported by Oyenuga (1968), stated that protein of millet grain is well supplied with amino acids and the seeds are good feed for poultry.

Two experiments were conducted to determine the effect of the energy-protein quality of pearl millet on performance of meat-strain chicks fed a practical basal diet. Weight gain and feed utilization from 0-5 weeks in Experiment I and 0-6 weeks in Experiment II were used as the criteria for evaluation of pearl millet as compared with sorghum grain.

REVIEW OF LITERATURE

Pearl millet [Pennisetum typhoides (Burm) Stapf and Hubbard] is considered by many agriculturists as an excellent emergency crop.

Wilson and Poley (1942) stated that proso millet, not a sorghum, was included in their experiment because it is an emergency crop that has a short growing period and a low water requirement. Its unusual characteristics as a grain that is tolerant of drought and heat makes it possible to produce grain in regions too hot and dry for other cereals.

Mukherjee and Parthasarathy (1947) pointed out that as poultry feed the digestible nutrients of five common cereal grains: cheena, ragi, barley, bajra (pearl millet), and jowar (sorghum vulgare) have been determined. Bajra (pearl millet) and Jowar (sorghum) were found to be equally superior to the other three grains in starch equivalent and digestibility.

Scientific literature revealed the use of pearl millet was scanty, and opinion varies concerning its relative feeding value as compared with other grains such as wheat maize or sorghum.

Freeman, as reported by Burton (1972) stated that a sample of tiflate pearl millet grain grown in south Texas contained 17.4, 4.9, and 61.5% of protein, oil, and starch, respectively, on a dry basis. He stated that corresponding values for commercial corn and commercial sorghum were 9.7, 4.5, and 72.0% and 10.7, 3.7, 73.8%, respectively. He also reported the starch properties of these three cereals were similar.

Mukherjee and Parthasarathy (1947) stated that millets may very well replace wheat in poultry rations. Such rations should be adjusted in other respects and tested carefully before adoption on large scale.

Burton, et al. (1972), presented evidence of equal or superior protein and oil content of pearl millet compared with wheat (triticu aestivium L.), corn (zea maize L.), sorghum (sorghum bicolor moench), and rice (oryza sativa L.).

An earlier study by Jellum and Powell (1971), pointed out that pearl millet grain is higher in oil content than most other cereals, and the fatty acid profiles of the oils in pearl millet and corn in Georgia were different. If the lines analyzed in this study represent the species, pearl millet oil is higher in palmitic, stearic, and linoleic acids and lower in oleic acid and linolenic acids than corn oil.

Lloyd (1964) concluded that chickens fed pearl millet rations were heavier and had better feed conversion than those fed maize rations. These differences were nonsignificant at the 1% level of probability.

Johnson (1969) comparing different grains found bulrush millet (pennisetum typhoides) contained 1.8, 8.0, and 80% of crude fiber, digestible protein and total digestible nutrients, respectively, as compared with sorghum that contained 2.1, 7.2, and 78% crude fiber, digestible protein and total digestible nutrients, respectively.

Variable protein levels have been reported in pearl millet grains. Wilson and Poley (1940) found protein content of South Dakota grown pearl millet averaged 14.66%. Oyenuga (1968) presented a table showing protein content from Nigerian pearl millet at 8.00 to 9.02%. Mukherjee and Parthasarathy (1947) analyzed a Georgia pearl millet grain and found it to vary from 6.19 to 8.33% in protein content.

Burton et al. (1972) observed wide variation among 180 inbred lines grown at the same time in a moderately tifton loamy sand, fertilized with 616 lb./acre of 4-12-12. The protein content of these samples ranged from 8.8 to 20.9%, and had a mean value of 16%. The same report stated the grain samples from pearl millet lines at the Indian Agricultural Research Institute in New Delhi, India, contained from 10.2 to 23.0% protein.

Adrian and Jacquot (1964) summarizing analyses of two varieties of pearl millet reported by different research workers showed protein contents ranging from 9.2 to 16.0%.

Analyses made by the Kansas State University Department of Grain Science and Industry on two samples of Kansas pearl millet reported protein contents ranging from 12.5 to 13.12% on a moisture free basis.

The genetic variability of protein content of pearl millet grain that many authors have observed between lines suggest that protein in millet grain can be increased by breeding. Burton et al. (1972) pointed out the obvious need to describe as accurately as possible, the nutritive value of pearl millet grain and the potential for its improvement by breeding. For this reason nutritionists have dedicated more research to emphasize the nutritive and biological values of pearl millet grain.

Mukherjee and Parthasarathy (1947) reported on studies of the biological values of protein on certain poultry feed. They observed that both the biological values and the digestibility coefficients of bajra (Pennisetum typhoides) is the richest, barley and ragi (eleusine coracana) next and jowar (sorghum) the poorest. The average biological values were 85, 82, 81 and 56%, respectively.

Pushpamma (1968) found that rats fed unsupplemented diets of pearl millet, ragi, sorghum, and corn, made the best growth rate on pearl millet. Chemical analysis of the grains fed suggested that ragi contained adequate amounts of all amino acids, but pearl millet was deficient in lysine. Sorghum grain was deficient in lysine, tryptophan, and sulfurbearing amino acids. Maize was deficient in lysine, tryptophan, isoleucine, and valine.

In another rat feeding experiment, Daniel et al. (1968) compared basic diets of pearl millet, ragi, and sorghum grain alone and with supplements of minerals, vitamins, pulses (legumes), and skim milk powder. All diets benefited from the supplements. The best growth rate in every instance was obtained from pearl millet, followed by ragi and then sorghum. Rats fed unsupplemented pearl millet gained 28.6% and 16.1% faster than rats fed unsupplemented sorghum and ragi, respectively. With the best supplement (9% skim milk powder plus vitamins and minerals), pearl millet produced weekly growth rates of 24.8 gm./animal, which was 25.6% and 18.1% better than sorghum grain and ragi, respectively.

Jansen *et al.* (1962) observed "by rat feeding, that supplementation of millet with lysine raised the protein efficiency ratio approximately to that obtained with casein." Their studies revealed a "good balance among essential amino acids except for being markedly first limiting in lysine."

The profiles of essential amino acids for pearl millet, and sorghum (Table 3) suggest that pearl millet is higher in all the essential amino acids except proline and leucine.

Since pearl millet exhibits more morphological variability than most cereals, and since it has exhibited a good range of lysine content in the feed samples analyzed, as reported by Burton *et al.* (1972), there is good reason to believe that its lysine content could be substantially increased by an extensive search for high-lysine varieties in the world's germ plasma, followed by an extensive breeding program.

Other workers have shown few variations in results when feeding pearl millet. Cooper (1948) found that pearl millet is very palatable, and should not be fed in too great quantities, especially to chickens, as it is likely to cause crop trouble. Burton and Milne (1961) reported that had chickens been able to digest the grain, then the feed consumption would have been increased. An examination of the droppings showed the presence of undigested grain. They noticed on examination, only a few millet grains in the dropping for the first 3 days of age, thereafter, practically no grains were found.

Parthasarathy and Mukherjee (1947) observed that an analysis of 35 substances used as common poultry feeds in India revealed that manganese content of bajra (pearl millet) was low compared with wheat-bran and rice-bran. Wilson and Poley (1940) reported that South Dakota pearl millet grain had a low content of manganese. Cooper (1948) stated that pearl millet grains contain enough Vitamin A to support normal growth which is important when white maize is fed and green feed is lacking.

Oyenuga (1968) considered pearl millet as a fairly good source of protein, low in minerals such as calcium, sodium, copper, and cobalt, but fairly high in phosphorus, potassium, and iron.

Smith (1967) reported that pearl millet was a valuable source of energy in poultry rations (having 3450 cal./kg.).

Wikinson et al. (1968) stated that pearl millet represents a potential xanthophyll source for commercial poultry feeds.

Burton et al. (1972) reported that pearl millet contains similar amounts of calcium and phosphorus and more iron than wheat, corn, sorghum grain and rice.

Hirokadsu (1968) working with different varieties of foxtail millet found a positive correlation between crude protein and glutamic acid and proline contents, but a negative correlation with lysine, aspartic acid, and arginine contents at 1% level of probability.

MATERIALS AND METHODS

Experiments I and II

The biological experiments were conducted at the Kansas State University Avery Research Center. A total of 480 birds were used. Experiment I consisted of 240 birds and was initiated on June 6, 1972 and ran until July 11, 1972. The second trial utilizing 240 birds was conducted from December 9, 1972 to February 6, 1973.

Day-old, male, meat-strain broiler chicks were wing-banded and placed on experiment in a completely randomized design of 6 diets with 4 lots per diet and 10 birds per lot, totaling 24 lots and 240 birds.

Electrically heated battery brooders were used to rear the birds to four weeks of age. Artificial light was provided from 6:00 a.m. to 8:00 p.m. daily in both experiments. Room and battery temperatures were thermostatically controlled according to recommendations for broiler management throughout the 4-week growing period, at which time they were transferred to unheated batteries for the balance of the experimental period. All diets were formulated on an equal dry matter basis. In Experiment I, diets 1, 2, and 3 were calculated to contain 17% protein and diets 4, 5, and 6 20% protein. In Experiment II, diets 1 and 2 were calculated to contain 17% protein and diets 3, 4, 5, and 6 20% protein. Glutamic acid (0.52%) was added to diet 3 for best amino acid balance as suggested in previous work by Sanford and Deyoe (1967).

Grain was ground and all ingredients were mixed as specified by the Kansas State University Department of Grain Science and Industry. Various supplements were added to the basal diets. The composition of these diets is given in Tables 1 and 2. All macroingredients and microingredients were weighed on a large platform balance and on a double pan computagram balance, respectively. The microingredients and fat supplement were added and mixed for 15 minutes in a 100-pound horizontal paddle mixer. This procedure was followed in both experiments.

Feed and water were provided ad libitum. Data were collected for chicks weight gains and feed consumption at 2-week intervals, except in Experiment I there was a 1-week interval between the 4th and 5th week period. Experiment I was terminated at the end of the 5th week as the supply of millet became exhaused. Diets were analyzed for protein content according to kjeldhal procedure, and chromatographic analysis for amino acids content. These analyses were made by Kansas State University Department of Grain Science and Industry and appear in Tables 3, 4, and 5. Feed utilization and weight gain data appear in Tables 6 and 7.

Statistical analysis of variance was run on 0-2, 2-4, 4-5, 0-4, and 0-5 week data for Experiment I, and 0-2, 2-4, 4-6, 0-4, and 0-6 week data for Experiment II. A nested analysis of variance with diets, lots within diets, and birds within lots within diets was used for both experimental diets and obtained also for each of the above criteria.

RESULTS

Experiment I

Weight gain and feed utilization were calculated, and an analysis of variance was run on the 0-2, 2-4, 4-5, 0-4 and 0-5 week data. The results obtained are summarized in Tables 8 and 9.

The weight gains for diets 4, 5 and 6 (20% protein) were highly significantly different than diets 1, 2 and 3 (17% protein) at 0-2, 2-4, 4-5, 0-4 and 0-5 weeks at 1% and 5% level of probability. There were significant differences in weight gain among diets 1, 2 and 3 at the 1% and 5% level of probability at 0-2, 2-4, 4-5, 0-4, and 0-5 week period.

However, there was no significant difference among diets 4, 5 and 6 for the various experimental periods.

The feed utilization values for diets 4, 5 and 6 (20% protein), were found to be significantly different than diets 1, 2 and 3 (17% protein) at 0-2, 2-4, 0-4 and 0-5, at both the 1% and 5% level of probability, but for the 4-5 week period no significant difference was found. In a comparison of feed utilization between diets 1, 2 and 3 there is no significant difference at 2-4, 4-5 week periods, but the 0-2, 0-4, and 0-5 week periods resulted in a slight difference at the 1% and 5% level of probability. Non-significant differences were obtained for feed utilization for rations 4, 5 and 6 for the 0-5 week duration of the experiment.

Experiment II

A slight modification was made for Experiment II. An analysis of variance was run on the 0-2, 2-4, 4-6, 0-4 and 0-6 week period (details are given in Tables 10 and 11).

The results for Experiment II were as follows:

Weight gain performance at 0-2, 2-4, 0-4, and 0-6 weeks period was significantly different between diets 1 and 2 (17% protein) at the 5% and 1% level of probability, but a nonsignificant difference was found for the 4-6 week period.

Compared to the performance of diets 1 and 2, a slight difference was found for the 0-2 week period at the 5% level of probability, but for the remainder of the growth period, 2-4, 4-6, 0-4, and 0-6, the statistical analysis did not show significant differences.

The analysis of variance for diets 3, 4, 5 and 6 shows a significant difference for weight gain at 0-2, 0-6 week period at the 5% level of probability, but nonsignificant differences were found at 2-4, 4-6 and 0-4 week periods.

Feed utilization data presented in Table 11 show a highly significant difference between diets 1 and 2 (17% protein) and diets 3, 4, 5 and 6 (20% protein) over the entire period (0-6 weeks) at the 5% and 1% level of probability.

Same results were found between diets 1 and 2 for the entire feeding period. Also no significant difference was found comparing diets 3, 4, 5 and 6 at 0-2, 2-4, 0-4 and 0-6 week periods, and a slight difference for the 4-6 week at the 5% level of probability. An LSD analysis was performed on the means in an attempt to determine where the differences were to be found.

DISCUSSION OF RESULTS

Evaluation of the results for the average weight gain and feed utilization are shown in Tables 8, 9, 10 and 11. An analysis of variance for Experiments I and II shows significant differences in mean weight gain and feed utilization for both periods of the experiment from beginning to end.

These results are in agreement with Lloyd (1964) who reported that birds fed pearl millet diets were heavier and had better feed conversion than those fed maize diets.

It is interesting to note that diets 4, 5 and 6 (20% protein) in the first experiment and 3, 4, 5 and 6 (20% protein) in the second experiment had better weight gain and feed utilization as compared with diets 1, 2 and 3 (17% protein) and 1 and 2 (17% protein) respectively. It is important to note that diets with the best performance were diets with high amounts of pearl millet. This gives evidence of the digestibility of the millet grain.

The author's view is in agreement with Burton and Milne (1961), who concluded that millet can be used extensively in all-mash chicken starter diets as a "meal" or as a whole grain.

From data presented in Tables 8, 9, 10 and 11, it can be seen there are no differences statistically among diets 4, 5 and 6 and 3, 4, 5 and 6 in Experiments I and II, respectively. This could be due to the same protein content (20%) and an adequate amino acid balance.

It is suggested the differences shown for diets 1, 2 and 3 in the first experiment and diets 1 and 2 for the second experiment could be due to the inability of the young chicks to cope with the slightly higher fiber content of the pearl millet such as in the case of diet 3 containing 81.14%

pearl millet. It is also correlated with the slightly lower calorie content of the pearl millet diets, and the lower quality of the amino acids present.

From the results, it is assumed that the significant differences shown here are due to differences in protein content of the diets, which were slightly higher (3%) in the case of diets 4, 5 and 6, and 3, 4, 5 and 6 for both experimental periods.

Since there are no previous works reported with feeding pearl millet and sorghum grain the author is restricted to his own results.

SUMMARY AND CONCLUSIONS

Two replicated experiments were conducted to study the performance of meat-strain chicks fed pearl millet or sorghum grain.

A total of 480 meat-strain male chicks were used in the two experiments. The chicks were kept in electrically heated battery brooders to four weeks of age. At four weeks they were transferred to unheated batteries until five weeks of age in Experiment I and six weeks of age in Experiment II.

Weight gain and feed utilization data were taken at two-week intervals during the experimental period. All diets were formulated on an equal dry matter basis to contain 17% protein or 20% protein.

There was significant difference in weight gain and feed utilization of birds fed pearl millet or sorghum grain as a source of energy and protein.

From analyses of the data resulting from this study, the following conclusions were made:

(1) Pearl millet performed better in diets 4, 5 and 6 with 20% protein compared with diets with 17% protein for both feed utilization and chick weight gain.

(2) There was no significant difference in feed utilization and weight gain for diets containing 20% protein and different quantities of soybean meal and sorghum grain. Thus, pearl millet can be used to replace sorghum grain for feeding meat-strain birds.

(3) There was a significant difference among the diets with 17% protein. Diet 2, containing 52.84% pearl millet performed better for weight gain and feed utilization in Experiment I than did diets 1 and 3. In Experiment II, diet 2 performed better for feed utilization than diets 1 and 3.

(4) Pearl millet had no depressing effect on growth and was not toxic apparently to poultry when used in high quantities.

(5) Pearl millet is interchangeable with sorghum grain and supplements in an all-mash chick-broiler starter and finisher diets.

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APPENDIX

Table 1. Composition of diets for Experiment I

Ingredients	DIETS					
	1[1]	2[1]	3[1]	4[2]	5[2]	6[2]
Soybean meal, 44% protein	15.39	15.39	7.36	24.51	17.08	18.76
Sorghum grain	73.11	---	---	63.99	---	---
Millet	---	52.84	81.14	---	71.42	65.74
Corn starch	---	20.27	---	---	---	---
Alfalfa	2.00	2.00	2.00	2.00	2.00	2.00
Fish meal	4.00	4.00	4.00	4.00	4.00	4.00
Distillers dried solubles	1.50	1.50	1.50	1.50	1.50	1.50
$CaCO_3$	1.00	1.00	1.00	1.00	1.00	1.00
DiCalcium phosphate	1.00	1.00	1.00	1.00	1.00	1.00
Salt	0.50	0.50	0.50	0.50	0.50	0.50
Fat	1.00	1.00	1.00	1.00	1.00	5.00
Premix[3]	0.50	0.50	0.50	0.50	0.50	0.50
TOTALS (lbs.)	100	100	100	100	100	100

[1] (17% protein)

[2] (20% protein)

[3] Added per 100 pounds of Diet

Vitamin A (10,000 USP units/gm)	20.0 grams
Vitamin D_3 (15,000 ICU/gm)	6.0 grams
B-complex (Merck 1233)[4]	34.0 grams
Choline chloride, 50% mix	22.7 grams
Vitamin B_{12} (Proferm-20)	11.4 grams
Methionine	22.7 grams
Aurofac 50 (R)	22.7 grams
Trace mineral mix (Z-5)[5]	22.7 grams
Carrier	64.8 grams

[4] Example - B Complex vitamin mix supplying in mg/lb: riboflavin 8,000; pantothenic acid 14,720; niacin 24,000; choline chloride 80,000.

[5] Example - Trace mineral mix containing ppm per pound; Mn 50; Fe 50; Cu 5; Co 0.5; I 1.5; Zn 25.

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Table 2. Composition of diets for Experiment II

Ingredients	DIETS 1[1]	2[1]	3[2]	4[2]	5[2]	6[2]
Soybean meal, 44% protein	15.38	15.38	23.81	20.51	17.08	18.76
Sorghum grain	73.10	---	63.99	63.99	---	---
Millet	---	52.84	---	---	71.42	65.74
Corn starch	---	20.27	0.17	---	---	---
Alfalfa, 17% dehy.	2.00	2.00	2.00	2.00	2.00	2.00
Fish meal	4.00	4.00	4.00	4.00	4.00	4.00
Distiller dried solubles	1.50	1.50	1.50	1.50	1.50	1.50
$CaCO_3$	1.00	1.00	1.00	1.00	1.00	1.00
Dicalcium	1.00	1.00	1.00	1.00	1.00	1.00
Salt	0.50	0.50	0.50	0.50	0.50	0.50
Fat	1.00	1.00	1.00	1.00	1.00	5.00
Premix[3]	0.50	0.50	0.50	0.50	0.50	0.50
Glutamic acid	---	---	0.53	---	---	---

[1] (17% protein)

[2] (20% protein)

[3] Added per 100 pounds of Diet

Vitamin A (10,000 USP units/gm)	20.0 grams
Vitamin D_3 (15,000 ICU/gm)	6.0 grams
B-complex (Merck 1233)[4]	34.0 grams
Choline chloride, 50% mix	22.7 grams
Vitamin B_{12} (Proferm-20)	11.4 grams
Methionine	22.7 grams
Aurofac 50 (R)	22.7 grams
Trace mineral mix (Z-5)[5]	22.7 grams
Carrier	64.8 grams

[4] Example - B Complex vitamin mix supplying in Mg/lb: riboflavin 8,000; pantothenic acid 14,720; niacin 24,000; choline chloride 80,000.

[5] Example - Trace mineral mix containing ppm per pound: Mn 50; Fe 50; Cu 5; Co 0.5; I 1.5; Zn 25.

(R) Registered trademark American Cyanamid, Princeton, N. J.

Table 3. Amino Acid Analysis*

	Sample 72-217 A	Sample 72-216 A
	SORGHUM	MILLET
Protein content =	9.40	13.00
Moisture content=	8.00	8.60

AMINO ACIDS

% Sample Gm per 100 Gm sample
as is moisture.

		Sorghum	Millet
1	Lysine	0.260	0.468
2	Histidine	0.241	0.340
3	Ammonia	0.262	0.330
4	Arginine	0.467	0.775
5	Aspartic Acid	0.751	0.061
6	Threonine	0.373	0.535
7	Serine	0.504	0.639
8	Glutamic Acid	2.234	2.472
9	Proline	0.832	0.770
10	Glycine	0.365	0.482
11	Alanine	0.995	1.014
12	Half Cystine	0.255	0.321
13	Valine	0.529	0.674
14	Methionine	0.174	0.240
15	Isoleucine	0.396	0.504
16	Leucine	1.388	1.274
17	Tyrosine	0.532	0.646
18	Phenylalanine	0.532	0.646

* For Experiment I

Table 4. Amino Acid Analysis*

72-5990 Deyoe. 3-13-73

MILLET

Protein content	= 12.500
Protein on moist free basis	= 13.12
Moisture content	= 4.70
Constant card no.	= 77
Total sample vol.	= 5.0
Vol. on long column	= 1.0
Sample weight	= 39.850

AMINO ACIDS	% Sample Gm per 100 Gm sample as is moisture
1 Lysine	0.404
2 Histidine	0.294
3 Ammonia	0.273
4 Arginine	0.653
5 Aspartic Acid	0.980
6 Threonine	0.483
7 Serine	0.565
8 Glutamic Acid	2.393
9 Proline	0.711
10 Glycine	0.449
11 Alanine	0.915
12 Half Cystine	0.334
13 Valine	0.578
14 Methionine	0.160
15 Isoleucine	0.465
16 Leucine	1.166
17 Tyrosine	0.420
18 Phenylalanine	0.605

Cystine by oxidation
Methionine by oxidation
Recovery kjeldhal protein basis (total % of sample/% kjeldhal protein) = 94.78
Recovery nitrogen basis
(total nitrogen recovered/kjeldhal nitrogen) = 86.48

*For Experiment II

Table 5. Amino Acid Analysis*

72-601A Deyoe. 2-15-73

SORGHUM

Protein content	=	9.900
Protein on moist free basis	=	10.77
Moisture content	=	8.10
Constant card no.	=	71
Total sample vol.	=	5.0
Vol. on long column	=	1.0
Sample weight		43.050

AMINO ACIDS	% Sample Gm per 100 Gm sample as is moisture
1 Lysine	0.212
2 Histidine	0.192
3 Ammonia	0.231
4 Arginine	0.395
5 Aspartic Acid	0.673
6 Threonine	0.326
7 Serine	0.454
8 Glutamic Acid	2.278
9 Proline	0.877
10 Glycine	0.312
11 Alanine	0.914
12 Half Cystine	0.217
13 Valine	0.463
14 Methionine	0.138
15 Isoleucine	0.367
16 Leucine	1.354
17 Tyrosine	0.406
18 Phenylalanine	0.526

Cystine by oxidation
Methionine by oxidation
Recovery kjeldhal protein basis
(total % of sample/% kjeldhal protein) = 104.39
Recovery nitrogen basis
(total nitrogen recovered/kjeldhal nitrogen) = 91.23

*For Experiment II

Table 6. Average five week weight gains and feed utilization for all lots in Experiment I

Diet no.	Lot no.	Gains in grams	kg. Feed per kg. gain
1	1	672.6	2.14
	2	701.7	2.07
	3	679.3	2.11
	4	667.8	1.94
		$\bar{x}$ = 680.3	$\bar{x}$ = 2.07
2	5	778.6	2.00
	6	763.0	2.12
	7	775.6	1.91
	8	812.8	1.93
		$\bar{x}$ = 782.5	$\bar{x}$ = 1.99
3	9	447.3	2.17
	10	513.1	2.10
	11	479.9	2.12
	12	361.8	2.30
		$\bar{x}$ = 450.5	$\bar{x}$ = 2.17
4	13	904.1	1.83
	14	867.3	1.83
	15	876.8	1.84
	16	921.1	1.87
		$\bar{x}$ = 892.3	$\bar{x}$ = 1.84
5	17	866.6	1.87
	18	905.5	1.82
	19	800.2	1.91
	20	839.9	1.75
		$\bar{x}$ = 853.1	$\bar{x}$ = 1.84
6	21	847.6	1.81
	22	975.2	1.77
	23	996.6	1.78
	24	827.6	1.74
		$\bar{x}$ = 911.7	$\bar{x}$ = 1.77

$\bar{x}$ Represents the average of 4 replicates.

Table 7. Average six week weight gains and feed utilization for all lots in Experiment II

Diet no.	Lot no.	Gains in grams	kg. Feed per kg. gain
1	1	1,021.8	2.46
	2	870.0	2.78
	3	957.8	2.51
	4	1,045.7	2.30
		$\bar{x}$ = 923.7	$\bar{x}$ = 2.51
2	5	---	---
	6	1,026.2	2.00
	7	935.4	2.58
	8	961.2	2.53
		$\bar{x}$ = 932.5	$\bar{x}$ = 2.37
3	9	1,054.3	2.36
	10	1,031.3	2.34
	11	1,134.9	2.36
	12	1,039.4	2.41
		$\bar{x}$ = 1,039.4	$\bar{x}$ = 2.36
4	13	1,099.7	2.25
	14	1,026.9	2.49
	15	1,002.9	2.40
	16	1,010.1	2.66
		$\bar{x}$ = 994.3	$\bar{x}$ = 2.45
5	17	1,162.2	2.30
	18	1,109.8	2.35
	19	1,107.4	2.34
	20	1,122.3	2.30
		$\bar{x}$ = 1,083.1	$\bar{x}$ = 2.32
6	21	1,298.6	2.05
	22	1,097.3	2.19
	23	1,185.7	2.14
	24	1,090.5	2.21
		$\bar{x}$ = 1,125.3	$\bar{x}$ = 2.14

$\bar{x}$ Represents the average of 4 replicates.

Table 8. One way analysis of variance for weight gain, Experiment I

Source of Variation	d.f.	MEAN SQUARE				
		0-2 wk.	2-4 wk.	4-5 wk.	0-4 wk.	0-5 wk.
Rations	5					
17% vs. 20% prot.	1	21,122.6**	95,190.5**	20,470.4**	212,440.2**	368,776.0**
R 1 vs. R 2 vs. R 3	2	3,599.9**	24,339.9**	12,087.8**	49,290.4**	115,644.8**
R 4 vs. R 5 vs. R 6	2	72.3^{ns}	593.3^{ns}	1,194.8^{ns}	1,569.3^{ns}	3,573.3^{ns}
Lots/Rations	18	198.8	434.8	720.8	948.7	2,491.8

Treatments	MEANS				
	0-2 wk. (gm.)	2-4 wk. (gm.)	4-5 wk. (gm.)	0-4 wk (gm.)	0-5 wk. (gm.)
R 1	141.3	293.4	248.1	452.8	680.3
R 2	169.4	348.1	258.1	522.3	782.5
R 3	109.4	194.2	158.3	305.0	450.5
R 4	201.5	398.5	292.2	630.2	892.3
R 5	196.1	396.6	260.2	592.5	853.1
R 6	200.8	418.5	287.3	621.9	911.7

** Significant at the 1% level of probability
ns Nonsignificant
LSD Values: 28.693 at the 1% level of probability at 0-2 wk.
42.438 at the 1% level of probability at 2-4 wk.
54.638 at the 1% level of probability at 4-5 wk.
62.683 at the 1% level of probability at 0-4 wk.
101.587 at the 1% level of probability at 0-5 wk.

Table 9. One way analysis of variance for feed utilization, Experiment I

		MEAN SQUARE				
Source of variation	d.f.	0-2 wk.	2-4 wk.	4-5 wk.	0-4 wk.	0-5 wk.
Rations	5					
17% vs. 20% prot.	1	0.293**	1.170**	0.119^{ns}	0.564**	0.397**
R 1 vs. R 2 vs. R 3	2	0.064**	0.063^{ns}	0.060^{ns}	0.030*	0.034**
R 4 vs. R 5 vs. R 6	2	0.004^{ns}	0.051^{ns}	0.024^{ns}	0.013^{ns}	0.006^{ns}
Lots/Rations	18	0.010	0.108	0.030	0.006	0.005

	MEANS				
Treatments	0-2 wk. (gm.)	2-4 wk. (gm.)	4-5 wk. (gm.)	0-4 wk. (gm.)	0-5 wk. (gm.)
R 1	1.63	2.23	2.18	2.00	2.07
R 2	1.55	2.48	2.01	1.98	1.99
R 3	1.78	2.37	2.55	2.14	2.17
R 4	1.42	2.05	1.94	1.79	1.84
R 5	1.47	1.88	2.09	1.73	1.84
R 6	1.41	1.83	1.98	1.68	1.77

** Significant at the 1% level of probability
* Significant at the 5% level of probability
ns Nonsignificant
LSD Values: 0.209 at the 1% level of probability at 0-2 wk.
0.154 at the 1% level of probability at 0-4 wk.
0.146 at the 1% level of probability at 0-5 wk.

Table 10. Unequal subclass analysis of variance for weight gain, Experiment II

Source of variation	d.f.	MEAN SQUARE 0-2 wk.	2-4 wk.	4-6 wk.	0-4 wk.	0-6 wk.
Rations	5					
17% vs. 20% prot.	1	78,602.6*	265,755.3**	11,851.3^{ns}	553,436.4**	688,983.0**
R 1 vs. R 2	1	4,588.6*	779.65^{ns}	2,715.8^{ns}	2,473.7^{ns}	10,001.05^{ns}
R 3 vs. R 4 vs. R 5 vs. R 6	3	3,681.7*	8,616.9^{ns}	95,621.9^{ns}	13,679.2^{ns}	147,084.3*
Lots/Rations	17	982.5	3,600.9	33,007.7	5,068.5	39,777.9
Birds/Lot	202	618.9	2,745.4	4,538.5	3,087.2	10,243.3

Treatments	MEANS 0-2 wk. (gm.)	2-4 wk. (gm.)	4-6 wk. (gm.)	0-4 wk. (gm.)	0-6 wk. (gm.)
R 1	151.5	357.0	423.3	509.4	923.7
R 2	167.9	350.2	410.6	521.6	932.5
R 3	205.7	408.9	409.6	612.3	1,007.8
R 4	200.4	434.6	375.5	616.4	994.3
R 5	184.6	426.9	472.0	611.2	1,083.1
R 6	204.7	444.3	477.6	648.5	1,125.3

** Significant at the 1% level of probability
* Significant at the 5% level of probability
ns Nonsignificant

LSD VALUES: 14.92 at the 1% level of probability at 0-2 wk.
95.20 at the 1% level of probability at 0-6 wk.

Table 11. One way analysis of variance for feed utilization, Experiment II

Source of variation	d.f.	MEAN SQUARE 0-2 wk.	2-4 wk.	4-6 wk.	0-4 wk.	0-6 wk.
Rations	5					
17% vs. 20% prot.	1	3.917**	9.723**	21.967**	7.823**	11.754**
R 1 vs. R 2	1	9.368**	13.32 **	26.59 **	1.865**	17.53 **
R 3 vs. R 4 vs. R 5 vs. R 6	3	0.100^{ns}	0.038^{ns}	0.361^{*}	0.066^{ns}	0.040^{ns}
Lots/Rations	17	0.046	0.029	0.098	0.027	0.025

Treatments	MEANS 0-2 wk (gm.)	2-4 wk. (gm.)	4-6 wk (gm.)	0-4 wk (gm.)	0-6 wk (gm.)
R 1	1.99	2.21	3.00	2.14	2.51
R 2	1.39	2.03	3.05	1.83	2.37
R 3	1.52	2.06	3.10	1.87	2.36
R 4	1.50	2.07	3.39	1.88	2.45
R 5	1.73	1.97	2.79	1.88	2.32
R 6	1.45	1.86	2.74	1.72	2.14

** Significant at the 1% level of probability
* Significant at the 5% level of probability
ns Nonsignificant
LSD Values: 0.346 at the 5% level of probability at 0-2 wk.
0.320 at the 5% level of probability at 4-6 wk.

A COMPARISON OF THE PERFORMANCE OF MEAT-STRAIN CHICKS FED PEARL MILLET OR SORGHUM GRAIN AS THE SOURCE OF ENERGY AND PROTEIN

by

FERNANDO CAMACHO-MENDEZ

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AN ABSTRACT OF A MASTER'S THESIS

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ABSTRACT

Two experiments were conducted using meat-strain chicks fed 6 different diets with 4 replicate lots per diet. Ten male chicks were used per lot and were reared on wire floored batteries. Feed and water were supplied *ad libitum*.

Criteria of measurements used were rate of gain and efficiency of utilization of the experimental diets.

In Experiment I highly significant differences were observed in rate of gain for the periods 0-2, 2-4, 4-5, 0-4, and 0-5 weeks of age. The experiment was terminated at the end of the fifth week. Highly significant differences were observed in the utilization of feed for the 0-2, 2-4, 0-4, and 0-5 week periods.

With Experiment II, significant differences in weight gain were observed for the periods 0-2, 2-4, 0-4, and 0-6 weeks of age. Significant differences were observed in the utilization of feed for the period 0-2, 2-4, 4-6, 0-4, and 0-6 weeks of age.

At equal protein levels, chick performance from millet was equal to sorghum grain. The amino acid profile, rate of chick weight gain and efficiency of utilization of feed were found to be favorable for the pearl millet as compared with sorghum grain as a source of energy and protein for broiler strain chicks.