effect of drought on nonprotein nitrogen was noticeable in each of the three succeeding years as well as in 1952, particularly in the southwestern part of the region, but drought areas were smaller than in 1953.

In 1957, weather conditions were more uniform, with no areas producing soybeans very high in nonprotein nitrogen and, in general, soybeans from northern areas tended to be slightly higher in nonprotein nitrogen, especially in areas where soybeans were slightly damaged by frost before they were mature. Unfavorable growing conditions, whether too cool and wet or too hot and dry, were associated with a high percentage of nonprotein nitrogen. Under drought conditions, growth may have been arrested before the seed was mature. Under these conditions, nitrogenous materials which would have normally developed into protein may have remained as nonprotein nitrogen in the harvested seed. Also, cool, wet weather appeared to have the same effect, that of increased nonprotein nitrogen in the seed, possibly because of slow and incomplete development. Wet weather continuing through the harvest season increased the probability of weather damage to the seed because of delayed harvesting and high moisture content. Under these conditions, weather damage may have caused breakdown of some protein, already formed, into nonprotein nitrogen compounds. Weather-damaged soybeans were often higher in nonprotein nitrogen than undamaged seed (*5*).

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NUTRITIVE VALUE OF CHICKEN MEAT

Nutritive Value of Chicken Meat and Its Value in Supplementing Rice Protein

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A study was made of the nutritive value of light and dark chicken meat and its effect on the improvement of whole and milled rice. The albino rat was used as the experimental animal. The protein efficiency of light and dark chicken meat has been determined. Data are presented on the value of the proteins of light and dark chicken meat in supplementing those of whole and milled rice and on the amino acid (essential and nonessential) content of light and dark chicken meat. The high nutritive value of chicken meat merits its continued promotion in its use for human foods and its recommendation for expansion of the broiler industry, where it is economically feasible.

HEPBURN, Sohn, and Devlin (*2*) found chicken meat to be less efficient than casein as a source of dietary protein and Millares and Fellers (*6*) reported that light chicken meat had higher protein content than dark chicken meat and that the biological value of proteins in chicken meat is equivalent to that of beef, pork, lamb, and veal. Since the latter investigators used yeast and liver extracts as a supplement to synthetic vitamins, it is possible that such extracts furnished supplementary nitrogen to the proteins of the various meats studied which might have influenced their results. Furthermore, little is known concerning the effect of chicken meat on the nutritional value of cereal grains, and although some information has been obtained on the content of essential amino acids, none is available on that of nonessential amino acids. It thus appears that information on the nutritive value of proteins in chicken meats is needed and is a new field for investigation.

This paper reports results of growth and metabolism experiments with young rats fed diets composed of light and dark chicken meat as the only source of protein. Included is a study on the effect of replacing rice proteins with those of chicken meat; 1, 3, and 5% of these solids replaced equivalent amounts of protein in whole brown and milled white rice rations which were fed to albino rats for 70 days. Another series of experiments was made on the effect of adding small amounts of these solids to rations containing whole brown and milled white rice as the only source of protein. Results are also presented of a study on the content of amino acids (including nonessentials) in light and dark chicken meat.

Experimental Procedure and Materials

In this study, 12 albino rats—sexes equally divided—were used for each group. The animals were about 28 days old when the experiments were started and weighed 50 to 54 grams each. Chicken meat and rice furnished the only sources of protein in the rations. The duration of the experiments was 10 weeks. The rations contained 4% of Sure's salt mixture No. 1 (*11*); 3% of hydrogenated vegetable shortening; 2% of cod liver oil; 1% of wheat germ oil; 2% of cellu flour; and the balance, percentagewise, was glucose (cerelose).

The fat-soluble vitamins A, D, and E were furnished by the cod liver oil and wheat germ oil in the rations. All rations were supplemented separately from the ration with a liberal supply of the B vitamins (*4*). The animals were weighed once weekly and accurate records were kept of food consumption. The protein efficiency ratios were determined from the calculated protein intake, expressed as gains in body weight per gram of protein intake.

Commercial rice samples were obtained from a rice mill in Stuttgart, Ark. They consisted of whole brown rice, which is rough rice from which the hulls are removed during milling, and of milled white rice, which is whole, brown rice from which the outer layers are removed during milling.

Broilers, 8 to 9 weeks old, of white, heavy-breasted Cornish Cross breed, bought from a local plant, furnished the chicken meat. The light chicken meat was obtained from breasts and wings, and the dark chicken meat from thighs and legs. Dried, fat-extracted chicken meat was used in the rations for growth, supplementation, and metabolism studies. Chicken meat was obtained by cutting it from frozen fryers, in small pieces, grinding it in a meat chopper, drying it at room temperature with the aid of fans, and extracting the fat with petroleum ether. The protein content of the fat-free light chicken meat was 86.6% (nitrogen × 6.25), of dark chicken meat 81.4%, of milled white rice 6.24% (nitrogen × 5.95), and of whole brown rice 7.25% (nitrogen × 5.95).

In the protein replacement experiments, the other solids were added at three levels—1, 3, and 5%; the proteins of these solids were added at the expense of the rice proteins, leaving the total protein in the ration the same. In protein addition experiments, solids were added also to the basal ration at these levels of 1, 3, and 5% at the expense of cerelose and the protein content was slightly increased.

In the study of the supplementary value of the proteins of light and dark chicken meat for those of whole brown rice, an equivalent amount of proteins of rice was replaced by the proteins of 1, 3, and 5% of light chicken meat, leaving the protein level of 6.38 (Table I, rations 2 and 4). In other experiments, 1, 3, and 5% of light and dark chicken meat were added, which increased the protein level to 6.39, 8.68, and 10.22, respectively (Table I, rations 1 and 7). In the study of the supplementary value of proteins of light and dark chicken meat to those of milled white rice, the procedure was similar to that described for whole brown rice. In replacement tests, the protein level was left at 5.46 (Table I, rations 9 and 11), and in addition tests, the protein level was increased from 5.46 to 6.20, 7.79, and 9.35%, respectively (Table I, rations 13 and 14). Results of these supplementary studies are given in Table I. Only one level of each supplement tested is listed; similar results were obtained on higher levels.

Results, expressed as average gain per animal (Table I), indicate that proteins of whole brown rice and milled white rice can be improved by supplementation with chicken meat solids. The values are higher in the combination whole rice–light chicken meat and whole rice–dark chicken meat than in each food separately and this constitutes a demonstration of a true supplementary relationship between two proteins (Table I, rations 1, 2, and 3). Results obtained from rations 1, 4, and 5, and 8, 9, 10

Table I. Supplementary Relationship between Light and Dark Chicken Meat and Whole and Milled Rice

(6 males and 6 females in each group, except in groups 15 and 16, 24 animals; average results per animal for a 10-week period)

	Ration	Protein in Ration, %	Gains in Body Weight: Grams	Gains in Body Weight: Increase, %	Protein Intake, Grams	Protein Efficiency Ratio[a]: Grams	Protein Efficiency Ratio[a]: Increase, %
1	Whole rice	6.38	82.3 ± 3.7	...	43.8	1.87 ± 0.03[b]	...
2	Whole rice + 3% light chicken	6.38	138.5 ± 8.7	68.2[c]	56.6	2.44 ± 0.10	30.4[c]
3	Light chicken meat	6.38	128.3 ± 2.8	...	56.0	2.30 ± 0.05	...
4	Whole rice + 3% dark chicken	6.38	139.3 ± 2.9	69.1[c]	51.8	2.69 ± 0.04	43.8[c]
5	Dark chicken meat	6.38	133.0 ± 3.5	...	53.1	2.50 ± 0.07	...
6	Whole rice + 3% light chicken	8.68	171.6 ± 5.0	108.5[c]	69.7	2.46 ± 0.17	31.5[c]
7	Whole rice + 3% dark chicken	8.68	176.3 ± 6.8	114.2[c]	71.4	2.47 ± 0.10	32.1[c]
8	Milled rice	5.46	73.0 ± 3.4	...	41.9	1.74 ± 0.03	...
9	Milled rice + 3% light chicken	5.46	130.0 ± 7.4	78.1[c]	50.5	2.57 ± 0.11	47.7[c]
10	Light chicken meat	5.46	90.8 ± 4.7	...	44.6	2.04 ± 0.09	...
11	Milled rice + 3% dark chicken	5.46	135.3 ± 6.4	85.3[c]	43.3	3.12 ± 0.10	85.3[c]
12	Dark chicken meat	5.46	119.5 ± 4.1	...	41.4	2.88 ± 0.14	...
13	Milled rice + 3% light chicken	7.79	169.2 ± 6.8	131.7[c]	72.0	2.35 ± 0.11	35.0[c]
14	Milled rice + 3% dark chicken	7.79	179.5 ± 5.6	145.9[c]	69.6	2.58 ± 0.08	48.2[c]
15	Light chicken meat	10.0	164.6 ± 3.8	...	86.9	1.89 ± 0.04	...
16	Dark chicken meat	10.0	177.2 ± 4.0	7.6[c]	92.9	1.90 ± 0.05	...

[a] Gain in body weight per gram of protein intake.
[b] Standard error.
[c] Significant for $P = 0.05$.

Table II. Effect of Chicken Meat on Biological Value of Whole and Milled Rice

Ad libitum feeding
6 males and 6 females in rations, except for 12 males and 12 females in rations 7 and 8; protein in rations 1, 2, and 3, 6.38%; in rations 4, 5, and 6, 5.46%; in rations 7 and 8, 9%; average results per animal given

Ration	Type	Biological Value,[a] %	True Digestibility,[b] %	Net Utilization,[c] %	Increase, %
1	Whole rice	88.1 ± 0.40	85.7 ± 0.30[b]	75.5 ± 0.60	...
2	Whole rice + 1% chicken meat	85.5 ± 0.58	92.3 ± 0.43	79.3 ± 0.80	5.0[e]
3	Whole rice + 3% light chicken	85.6 ± 2.80	93.7 ± 0.3	80.2 ± 1.2	6.2[e]
4	Milled rice	72.7 ± 0.70	88.8 ± 0.30	64.1 ± 0.80	...
5	Milled rice + 1% chicken meat	85.5 ± 0.78	92.8 ± 0.53	79.1 ± 1.00	23.6[e]
6	Milled rice + 3% light chicken	83.7 ± 2.7	92.7 ± 0.30	77.4 ± 0.98	20.7[e]
7	Light chicken meat	72.4 ± 0.83	93.2 ± 0.44	67.4 ± 1.1	...
8	Dark chicken meat	78.0 ± 0.70	92.3 ± 0.17	71.9 ± 0.8	6.68[e]

[a] Per cent absorbed nitrogen retained in animal body.
[b] True coefficient of digestibility obtained by subtracting nitrogen lost in feces from total nitrogen intake and dividing by 100.
[c] Obtained by multiplying true coefficient of digestibility by biological value and dividing by 100.
[d] Standard error.
[e] Significant for $P = 0.05$.

Table III. Determination of Amino Acids

	In Fat-Free Light Chicken Meat,[a] %		In Fat-Free Dark Chicken Meat,[b] %	
	In dry matter	In protein	In dry matter	In protein
Alanine	2.40	2.76	2.50	3.07
Arginine[c]	5.25	6.03	5.50	6.76
Aspartic acid	7.60	8.74	7.62	9.37
Cystine	0.90	1.03	0.90	1.11
Glutamic acid	13.2	.15.18	13.4	16.48
Glycine	4.80	5.52	4.79	5.89
Histidine[c]	2.05	2.35	2.02	2.48
Isoleucine[c]	4.50	5.17	4.60	5.66
Leucine[c]	6.00	6.90	6.10	7.50
Lysine[c]	6.25	7.18	6.27	7.71
Methionine[c]	2.20	2.53	2.16	2.65
Phenylalanine[c]	3.20	3.68	3.18	3.91
Proline	3.30	3.79	3.40	4.18
Serine	2.76	3.17	2.61	3.21
Threonine[c]	3.4	3.91	3.20	3.94
Tryptophan[c]	0.94	1.08	0.90	1.11
Tyrosine	2.60	3.07	2.62	3.09
Valine[c]	3.9	4.48	3.92	4.82

[a] 86.6% protein.
[b] 81.4% protein.
[c] Nutritionally essential.

provide proof of a true supplementary relationship between the proteins of milled white rice and those of light and dark chicken meat. The values are higher in the combination milled white rice–light chicken meat and milled white rice–dark chicken meat than in each food separately and this again constitutes a demonstration of a true supplementary relationship (Table I, rations 8, 9, 10, and 8, 11, and 12). Differences were tested statistically and found to be significant for $P = 0.05$.

A small, statistically significant difference was obtained between the growth value of dark chicken meat and light chicken meat, as is shown in results obtained from rations 15 and 16 where these meats were fed at a 10% protein level, using 24 test animals. The slight difference in amino acid content and possible differences in availability of amino acids might explain this. Animals fed extracted light and dark chicken meat showed an average gain of 164 and 177 grams and a protein efficiency ratio (P.E.R.) of 1.89 and 1.90, respectively, which is higher than the values of 142 grams and P.E.R. of 1.78 found for whole egg at a 9% protein level of intake and similar to values reported for whole milk, nonfat dry milk solids, and lactalbumin (*5*). From these results, it can be concluded that chicken meat is a good supplement for milled white and whole brown rice. People in areas with large rice consumption can benefit from this, when chicken meat is available at a reasonable cost. It indicates the desirability and importance of expansion of the poultry industry in various parts of the world and particularly in those countries where protein shortage and deficiency exist, which are responsible for high infant mortality and short life expectancy (*9*).

Table II shows biological values, true digestibility, and net utilization values of light and dark chicken meat at a 9% protein level and of whole brown and milled rice supplemented with and without additions of 3% of light chicken meat (rations 3 and 6) and of a mixture of 1% of light and dark chicken meat (rations 2 and 5), as determined by the nitrogen retention method of Mitchell (*7*). The net utilization values are obtained by multiplying the true coefficient of digestibility by biological values and dividing by 100. The resulting values are higher for the proteins of milled and whole rice supplemented by chicken meat (Table II, rations 2, 3, 5, and 6), and the differences were statistically significant for $P = 0.05$. Results of the metabolism experiments can explain differences in growth-promoting values of meat proteins found in the growth experiments. The meat-supplemented rice was more efficiently utilized and promoted better growth as a result of the smaller losses of nitrogen during metabolism.

Amino Acid Content. A complete description of the experimental procedure for the determination of amino acids has been presented (*3*). Results in fat-free samples of white and dark chicken meat, expressed as percentages of dry material and also as percentage of crude protein, are given in Table III. The content of essential amino acids agrees well with that reported elsewhere (*1, 6, 8*).

Table III shows that the proteins of light and dark chicken meat have much higher amino acid content than rice proteins, values of which have been reproduced in a previous paper (*5*). Tryptophan, lysine, threonine, and the combination of cystine and methionine are much lower in rice proteins and it might be assumed that these amino acids are mainly responsible for the high supplementary effect observed in the growth experiments, especially as lysine and threonine are considered to be the main limiting amino acids in rice proteins (*10*).

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