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Effects of Different Nutritional Plans on Broiler Performance

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ABSTRACT

An experiment was carried out at the Department of Animal Science of the Federal University of Viçosa, Brazil, to evaluate the effects of different nutritional plans on the performance of male and female Ross broilers. A completely randomized experimental design with a 6x2 factorial arrangement (six nutritional plans x two sexes) with six replicates of 20 birds per experimental unit was applied. The nutritional plans adopted for males and females included 3, 5, or 28 feeds, and the other 3 plans included 28 feeds containing 92.5, 100, and 107.5% of digestible lysine requirements established according to a mathematical model developed exclusively for Ross broilers. The results showed that the tested 28-feed feeding programs are equivalent, and allow similar performance as compared to 3- and 5-feed feeding programs. Based on the lysine levels included in the different nutritional plans, it was possible to fit the equations: $Y = -0.0079x + 1.2435$ ($R^2 = 0.981$) for males and $Y = -0.0084x + 1.1925$ ($R^2 = 0.978$) for females, where "Y" is digestible lysine level (%) and "x" is average age in days. These equations are specific for multiple-phase feeding programs. The performance of male and female broilers fed the lysine levels established by the mathematical models was similar as to that of birds fed the other nutritional plans. This demonstrates that it is possible to determine broiler lysine

INTRODUCTION

Broiler nutritional requirements are traditionally established using experiments, where a limiting nutrient is added to the feed, whereas all other nutrients are maintained in adequate levels. The level of the studied nutrient that maximizes growth rate or feed conversion ratio is then considered its requirement for a determined rearing phase. However, this level represents the average requirement for that phase, which means that broilers are fed suboptimal levels of that nutrient in the beginning of the rearing phase, whereas they are overfed at the end. Specifically in terms of amino acids, the initial deficiency prevents maximum protein accretion, and the excess at the end of the rearing phase results in nutrient waste and generates additional calorie expenditure in order to excrete amino acids in the urine. One solution for this problem is the adoption of a higher number of diets during the bird's lifetime, decreasing the differences between nutrient requirement and supply, resulting in higher protein deposition, lower use of amino acids during the different feeding phases, as well as lower nitrogen excretion, which is considered an important environmental pollution problem today.

Typical feeding programs for broilers include 3 to 5 diets, but these are not able to allow the maximum expression of the bird's genetic potential brought by genetic improvement. In order to ensure proper bird development, daily feeding programs would be recommended; however, this is still unfeasible under commercial conditions. Perhaps in the future, new technologies allowing multiple feeding programs will be created.

There are several research studies on broiler multiple-phase feeding programs, where feeds were changed every two to seven days. The authors of those studies concluded that these programs do not impair bird performance or carcass traits, and allow significant reduction of feed cost (Warren & Emmert, 2000; Pope & Emmert, 2001, and Pope *et al*., 2001).

When formulating diets for multiple-phase feeding programs, researchers have developed mathematical models based on nutritional requirements determined in experiments (Emmert & Baker, 1997 and Rostagno *et al*., 2000) or in growth or protein-deposition curves (Ivey, 1999).

The aim of the present experiment was to evaluate the effects of different nutritional plans on the performance of male and female broilers during the starter, grower, and finisher phase; to validate digestible lysine requirements established by mathematical models for male and female Ross broilers; and to evaluate the possibility of formulating 28 diets by diluting 2 different diets.

MATERIAL AND METHODS

The experiment was carried out in the experimental poultry house of the Department of Animal Science of the Federal University of Viçosa, Brazil. A number of 1440 one-day-old Ross chicks, half males and half females, with average initial weight of 43.1 g and 43.8 g, respectively, was used.

A completely randomized experimental design was applied. Treatments consisted of the nested effects of six nutritional plans within sex, with six replicates of 20 birds per experimental unit.

Birds were housed in an open-sided masonry poultry house divided into 72 pens (1.0 x 2.0 m). The poultry house was 3-m high, covered with asbestos tiles, and had concrete floor, sides with a 0.40-m wall and wire mesh, and an exhaustion chimney and plastic curtains to control temperature and drafts. Wood shavings were used as litter material.

Drinkers, feeders, curtains, and birds were managed according to the recommendations of Ross broilers management manual (Agroceres, 2000). Feed and water were offered *ad libitum* during the entire experimental period.

Table 1 shows the weekly average temperature and humidity in the poultry house during the experimental period.

Male and female broiler digestible lysine requirements were estimated by a mathematical model developed according to the following steps: (1) a body growth curve and a daily weight gain curve (Gompertz equation) were built based on the data presented in the genetic line manual (Agroceres, 2000). The equation parameters were determined using the Gauss-Newton procedure of the SAEG software (UFV, 1999) and are presented in Table 2.

Table 2 - Gompertz equation parameters fit for male and females Ross broiler body weight.

Parameters[1]	Males	Females
A	6893.2	4694.0
B	0.0370	0.0409
C	42.1	36.4
R^2	1.000	1.000

[1]A = mature body weight (g); B = maximum growth rate (g/day per g); C = age at maximum growth rate (days).

(2) Determination of daily protein deposition rate (Gompertz equation) based on the data obtained in the performance experiment. The equation parameters were determined using the Gauss-Newton procedure of the SAEG software (UFV, 1999) and are presented in Table 3.

Table 1 - Maximum, minimum, and average temperature and humidity inside the poultry house during the experimental period.

Period (days)	Temperature (°C)			Humidity (%)		
	Max.	Min.	Average	Max.	Min.	Average
01 - 07	32.6	26.0	29.3	76.38	62.82	69.60
08 - 14	30.0	24.9	27.5	79.86	59.71	69.79
15 - 21	28.6	24.5	26.5	82.00	64.14	73.07
22 - 28	28.4	20.8	24.6	88.57	61.14	74.86
29 - 35	28.7	22.4	25.5	91.00	67.29	79.14
36 - 42	29.9	20.0	24.9	91.86	54.29	73.07
43 - 49	30.9	20.2	25.6	94.43	48.71	71.57
50 - 56	31.4	19.9	25.7	95.14	51.86	73.50

Table 3 - Gompertz equation parameters fit for male and females Ross broiler protein deposition.

Parameters[1]	Males	Females
A	1536.4	1165.4
B	0.0413	0.0403
C	40.8	38.8
R^2	1.000	1.000

[1]A = mature protein content (g); B = maximum rate of protein deposition (g/day per g); C = age at maximum protein gain (days).

(3) In order to determine daily digestible lysine requirement, the adapted equation of Dritz *et al*. (1997) was used, and maintenance lysine requirements, efficiency of lysine deposition, and lysine percentage in bird body protein used the values established by Edwards *et al*. (1999) associated to the data of the curves determined in steps 1 and 2.

DLR = Rm + (PrG x LTP / EDL)

where: DLR = digestible lysine requirement (g/bird/day); Rm = maintenance lysine requirement (g) (6.9 mg/day/$kg^{3/4}$); PrG = daily protein gain (g) (Gompertz equation, step 2); LTP: % of lysine in body protein (6.70 %); EDL: efficiency of digestible lysine deposition (79.3 %)

(4) Determination of daily feed intake based on data of the genetic line manual (Agroceres, 2000) corrected by a factor based on the studies of Barboza (1998) and Costa (2000).

CF = - 0.001t + 1.0742

where, CF = correction factor (value to which the feed intake presented in the manual is multiplied); t = bird age in days.

(5) By relating the daily requirements established in step 3 to the daily feed intake calculated in step 4, equations that allowed estimating digestible lysine requirements, expressed in %, for male and female Ross broilers were established. The equations are presented below:

Males: Y = - 0.0115X + 1.4454;
Females: Y = - 0.0124X + 1.4047;

where, Y = digestible lysine requirements (%); X = age in days.

(6) Considering that the remaining amino acids are added to the feed on lysine basis, their requirements were also estimated for the different bird ages.

The nutritional plans used during the entire experimental period are described in Table 4.

Table 4 - Nutritional plans (NP) used during the experimental period as a function of sex.

Nutritional Plan	Males
NP1	3 feeds (1-21 d; 22-42 d; e 43-56 d)[1]
NP2	5 feeds (1-8 d; 9-21 d; 22-33 d; 34-42 d; e 43-56 d)[1]
NP3	28 feeds (one every 2 days)[2]
NP4	28 feeds (one every 2 days)[3]
NP5	28 feeds (one every 2 days)[4]
NP6	28 feeds (one every 2 days)[5]
	Females
NP7	3 feeds (1-21 d; 22-42 d; e 43-56 d)[1]
NP8	5 feeds (1-8 d; 9-21 d; 22-33 d; 34-42 d; e 43-56 d)[1]
NP9	28 feeds (one every 2 days)[2]
NP10	28 feeds (one every 2 days)[3]
NP11	28 feeds (one every 2 days)[4]
NP12	28 feeds (one every 2 days)[5]

[1]Nutritional levels according to Rostagno *et al*. (2000). [2]Estimated nutritional levels based on the equations established by Rostagno *et al*. (2000). [3]92.5% digestible lysine level established by mathematical models. [4]100% digestible lysine level established by mathematical models. [5]107.5% digestible lysine level established by mathematical models.

The experimental feeds of nutritional plans 1, 2, and 3 for males and 7, 8, and 9 for females were formulated to supply the digestible lysine requirements determined by Rostagno *et al*. (2000). The feeds of nutritional plans 4, 5, and 6 for males and 10, 11, and 12 for females contained, respectively, 92.5, 100, and 107.5% of the digestible lysine requirements established by mathematical models fit exclusively for Ross broilers. Digestible lysine requirements for the nutritional plans 3, 4, 5, and 6 for males and 9, 10, 11, and 12 for females are presented in Table 5.

The remaining nutrients were added to diets according to the recommendations of Rostagno *et al*. (2000), and the following amino acid:digestible lysine ratios adopted in all nutritional programs were: digestible methionine + cystine 71%; digestible threonine 67%; digestible arginine 110%; digestible tryptophan 17%; and total glycine + serine 183.8%.

The 28-feed nutritional plan used the technique of dilution, i.e., diets were formulated according to the requirements of one-day-old and 55-day-old birds, and the other feeds were obtained by mixing different proportions of the formulated diets.

The nutritional values of the experimental diets, based on corn and soybean meal, are presented in Tables 6, 7, and 8.

Table 5 - Digestible lysine requirements (%) as a function of bird age and nutritional plan.

Age (days)	Nutritional plans							
	Males				Females			
	NP3[1]	NP4[2]	NP5[3]	NP6[4]	NP9[1]	NP10[2]	NP11[3]	NP12[4]
1	1.201	1.326	1.434	1.541	1.141	1.288	1.392	1.497
3	1.190	1.305	1.411	1.517	1.131	1.265	1.368	1.470
5	1.180	1.284	1.388	1.492	1.121	1.242	1.343	1.443
7	1.169	1.263	1.365	1.467	1.110	1.219	1.318	1.417
9	1.158	1.241	1.342	1.443	1.100	1.196	1.293	1.390
11	1.147	1.220	1.319	1.418	1.090	1.173	1.268	1.363
13	1.136	1.199	1.296	1.393	1.079	1.150	1.244	1.337
15	1.125	1.177	1.273	1.368	1.069	1.127	1.219	1.310
17	1.114	1.156	1.250	1.344	1.058	1.104	1.194	1.283
19	1.102	1.135	1.227	1.319	1.047	1.081	1.169	1.257
21	1.091	1.114	1.204	1.294	1.036	1.058	1.144	1.230
23	1.079	1.092	1.181	1.269	1.025	1.036	1.120	1.203
25	1.067	1.071	1.158	1.245	1.014	1.013	1.095	1.177
27	1.056	1.050	1.135	1.220	1.003	0.990	1.070	1.150
29	1.044	1.029	1.112	1.195	0.991	0.967	1.045	1.123
31	1.032	1.007	1.089	1.171	0.980	0.944	1.020	1.097
33	1.020	0.986	1.066	1.146	0.969	0.921	0.996	1.070
35	1.007	0.965	1.043	1.121	0.957	0.898	0.971	1.044
37	0.995	0.943	1.020	1.096	0.945	0.875	0.946	1.017
39	0.983	0.922	0.997	1.072	0.933	0.852	0.921	0.990
41	0.970	0.901	0.974	1.047	0.922	0.829	0.896	0.964
43	0.957	0.880	0.951	1.022	0.910	0.806	0.872	0.937
45	0.945	0.858	0.928	0.997	0.897	0.783	0.847	0.910
47	0.932	0.837	0.905	0.973	0.885	0.760	0.822	0.884
49	0.919	0.816	0.882	0.948	0.873	0.737	0.797	0.857
51	0.906	0.794	0.859	0.923	0.861	0.714	0.772	0.830
53	0.893	0.773	0.836	0.899	0.848	0.691	0.748	0.804
55	0.880	0.752	0.813	0.874	0.836	0.668	0.723	0.777

[1]Estimated nutritional levels based on the equations established by Rostagno *et al.* (2000). [2]92.5% digestible lysine level established by mathematical models. [3]100% digestible lysine level established by mathematical models. [4]107.5% digestible lysine level established by mathematical models.

Table 6 - Nutritional values of male (NP1) and female (NP7) feeds for 3 nutritional plans.

	SF*	GF*	FF*
NP1			
Protein, %	21.999	20.000	18.000
ME (kcal/kg)	3000	3100	3200
Digestible lysine, %	1.148	1.024	0.917
NP7			
Protein, %	22.000	19.000	17.000
ME (kcal/kg)	3000	3100	3200
Digestible lysine, %	1.091	0.972	0.871

*SF: starter feed (1-21 days); GF: grower feed (22-42 days); and FF: finisher feed (43-56 days).

The following parameters were evaluated: weight gain, feed intake, feed conversion ratio, and mortality. At 42 and 56 days of age, production factor was also evaluated.

The equation used to determine the production factor (PF) was:

$$PF = (((WG/A)*L)/FCR)*100$$

where, WG = weight gain (Kg); A = age (days); L = livability (%); FCR = feed conversion ratio.

For the analyses of variance of the periods 22 to 42 and 22 to 56 days, weight at 21 days was used as covariate, whereas weight at 42 days was used for the period of 43 to 56 days of age.

The parameters were statistically analyzed using the SAEG software package (UFV, 1999). Means were compared by the Student-Newman-Keuls test at 5% significance level.

RESULTS AND DISCUSSION

Tables 9 and 10 show the results of the performance 1- to 21-day-old male and female broilers, respectively, as a function of nutritional plan.

The tested nutritional plans significantly influenced male and female feed intake and feed conversion ratio, but did not affect their weight gain or livability.

In males, the feed intake promoted by nutritional plan NP2 was higher as compared to NP4 and NP5, and was similar to NP1, NP3, and NP6. NP3 and NP6 nutritional plans resulted in better feed conversion ratio than NP1 and NP2, but these four plans were not different from NP4 or NP5.

Table 7 - Nutritional values of male (NP2) and female (NP8) feeds for 5 nutritional plans.

	PSF*	SF*	GF1*	GF2*	FF*
NP2					
Protein, %	22.800	21.700	20.346	19.258	18.067
ME (kcal/kg)	2950	3010	3075	3100	3175
Digestible lysine, %	1.181	1.126	1.050	0.977	0.909
NP8					
Protein, %	22.800	21.700	19.768	18.400	16.901
ME (kcal/kg)	2950	3010	3075	3100	3175
Digestible lysine, %	1.122	1.069	0.997	0.928	0.864

*PSF: pre-starter feed (1-8 days); SF: starter feed (9-21 days); GF1: grower feed 1 (22-33 days); GF2: grower feed 2 (34-42 days); and FF: finisher feed (43-56 days).

Table 8 - Nutritional values of males (NP3, NP4, NP5, and NP6) female (NP9, NP10, NP11, and NP12) feeds for 28 nutritional plans.

	F 1D*	F 55D*	F 1D*	F 55D*
	NP3		**NP4**	
Protein, %	23.091	17.497	23.325	17.497
ME (kcal/kg)	2946	3226	2946	3226
Digestible lysine, %	1.205	0.884	1.326	0.788
	NP5		**NP6**	
Protein, %	23.527	17.497	23.729	17.497
ME (kcal/kg)	2946	3226	2946	3226
Digestible lysine, %	1.434	0.813	1.541	0.874
	NP9		**NP10**	
Protein, %	23.090	16.200	23.091	16.200
ME (kcal/kg)	2946	3226	2946	3226
Digestible lysine, %	1.145	0.839	1.288	0.704
	NP11		**NP12**	
Protein, %	23.544	16.200	23.741	16.200
ME (kcal/kg)	2946	3226	2946	3226
Digestible lysine, %	1.392	0.723	1.497	0.777

*F 1D: feed formulated to supply the requirements of 1-day-old birds; F 55D: feed formulated to supply the requirements of 55-day-old birds.

In females, feed intake and feed conversion ratio of birds fed NP7 and NP8 were not different, but presented higher values as compared to the other treatments (NP9, NP10, NP11, NP12), which presented similar values.

The results clearly show that the nutritional plans that included a lower number of diets, such as NP1 and NP2 for males, and NP7 and NP8 for females, presented the worst match between requirement and supply. This is demonstrated by the higher feed intake to ensure adequate nutrient ingestion because theses birds receive suboptimal nutrient levels during the second half of the evaluated phase. This is also evident when the results of NP1 and NP2 are compared to those obtained with NP3 and NP9, where, despite containing similar digestible lysine level, resulted in different feed intake.

As there was no difference in weight gain among the different plans, the higher feed intake led to worse feed conversion ratio in the plans that included a lower number of diets. The multiple-phase feeding programs proved to be more efficient in ensuring a better nutrient utilization. These results are consistent with those observed by Warren & Emmert (2000) for weight gain; however, they disagree in terms of feed intake and feed conversion ratio.

Tables 11 and 12 show the results of the performance 22- to 42-day-old male and female broilers, respectively, as a function of nutritional plan.

There was no significant effect of the tested nutritional plans on male and female weight gain, feed

Table 9 - Effect of the nutritional plans on the performance of 1- to 21-day-old male Ross broilers[1].

Nutritional Plan[2]	Feed intake (g)	Weight gain (g)	Feed conversion ratio	Livability(%)
NP1	1222.7 ab	789.9	1.548 b	97.50
NP2	1266.7 a	820.9	1.543 b	98.33
NP3	1221.4 ab	835.1	1.463 a	99.17
NP4	1182.9 b	792.5	1.493 ab	98.33
NP5	1198.2 b	799.8	1.498 ab	100.00
NP6	1218.3 ab	828.0	1.471 a	99.17
CV(%)	3.33	4.30	2.82	2.37

[1]Means followed by different letters in the same column are different by the Student-Newman-Keuls test (P<0.05).[2]NP1 = 3 feeds (Rostagno *et al.*, 2000); NP2 = 5 feeds (Rostagno *et al.*, 2000); NP3 = 28 feeds (Rostagno*et al.*, 2000); NP4 = 28 feeds (92.5% of the mathematical model); NP5 = 28 feeds (100% of the mathematical model); NP6 = 28 feeds (107.5% of the mathematical model). CV (coefficient of variation).

Table 10 - Effect of the nutritional plans on the performance of 1- to 21-day-old female Ross broilers[1].

Nutritional Plan[2]	Feed intake (g)	Weight gain (g)	Feed conversion ratio	Livability(%)
NP7	1250.3 a	748.8	1.670 b	99.07
NP8	1231.8 a	746.3	1.651 b	98.15
NP9	1142.3 b	745.1	1.533 a	100.00
NP10	1148.7 b	764.6	1.502 a	100.00
NP11	1167.3 b	783.9	1.489 a	98.15
NP12	1141.8 b	753.0	1.516 a	99.07
CV(%)	3.33	4.30	2.82	2.37

[1]Means followed by different letters in the same column are different by the Student-Newman-Keuls test (P<0.05). [2]NP7 = 3 feeds (Rostagno *et al.*, 2000); NP8 = 5 feeds (Rostagno *et al.*, 2000); NP9 = 28 feeds (Rostagno *et al.*, 2000); NP10 = 28 feeds (92.5% of the mathematical model); NP11 = 28 feeds (100% of the mathematical model); NP12 = 28 feeds (107.5% of the mathematical model). CV (coefficient of variation).

Table 11 - Effect of the nutritional plans on the performance of 22- to 42-day-old male Ross broilers[1].

Nutritional Plan[2]	Feed intake (g)	Weight gain (g)	Feed conversion ratio
NP1	3485.6	1641.6	2.123
NP2	3567.8	1639.2	2.177
NP3	3536.9	1630.3	2.169
NP4	3507.5	1644.9	2.132
NP5	3484.8	1648.1	2.114
NP6	3495.0	1637.1	2.135
CV(%)	2.78	2.95	2.54

[1](P>0.05). [2]NP1 = 3 feeds (Rostagno *et al*., 2000); NP2 = 5 feeds (Rostagno *et al*., 2000); NP3 = 28 feeds (Rostagno *et al*., 2000); NP4 = 28 feeds (92.5% of the mathematical model); NP5 = 28 feeds (100% of the mathematical model); NP6 = 28 feeds (107.5% of the mathematical model).CV (coefficient of variation).

Table 12 - Effect of the nutritional plans on the performance of 22- to 42-day-old female Ross broilers[1].

Nutritional Plan[2]	Feed intake (g)	Weight gain (g)	Feed conversion ratio
NP7	3044.3	1317.9	2.310
NP8	3096.8	1361.0	2.275
NP9	3048.3	1345.8	2.265
NP10	3047.5	1326.4	2.298
NP11	3064.2	1332.8	2.299
NP12	3036.3	1363.9	2.226
CV(%)	2.78	2.95	2.54

[1](P>0.05). [2]NP7 = 3 feeds (Rostagno *et al*., 2000); NP8 = 5 feeds (Rostagno *et al*., 2000); NP9 = 28 feeds (Rostagno *et al*., 2000); NP10 = 28 feeds (92.5% of the mathematical model); NP11 = 28 feeds (100% of the mathematical model); NP12 = 28 feeds (107.5% of the mathematical model).CV (coefficient of variation).

intake, or feed conversion ratio during the evaluated period.

The absence of bird response to the different nutritional plans shows that during this phase, multiple-phase feeding programs, represented by plans NP3 to NP6 for males and NP9 to NP12 to females, do not impair bird performance. Similar results were obtained by Pope & Emmert (2002) for weight gain and feed intake, but feed conversion results were different.

Considering that the nutritional plans NP5 and NP6 for males and NP11 and NP12 for females presented higher average digestible lysine levels as compared to the other plans, this lack of response to increasing lysine levels was also observed by Mendes *et al*. (1997), Buteri (2001), and Ojano-Dirain & Waldroup (2002), whereas Holsheimer & Ruensink (1993), Renden *et al*. (1994), and Ajinomoto (2003) obtained different results.

Tables 13 and 14 show the results of the performance 43- to 56-day-old male and female broilers, respectively, as a function of nutritional plan.

The nutritional plans significantly influence male weight gain and females feed conversion ratio. On the other hand, male and female feed intake, male feed conversion ratio, and female weight gain were not influenced by the experimental treatments.

In males, NP1 resulted in higher weight gain, as compared to NP3 and NP5; however, these were not different from NP2, NP4, or NP6. In females, NP8 promoted better feed conversion ratio than NP10, but these were not different from the remaining plans (NP7, NP9, NP11, or NP12).

The worst feed conversion ratio presented by females in NP10 could have been caused by the average dietary lysine level, which was the lowest of

Table 13 - Effect of the nutritional plans on the performance of 43- to 56-day-old male Ross broilers[1].

Nutritional Plan[2]	Feed intake (g)	Weight gain (g)	Feed conversion ratio
NP1	2788.1	970.9 a	2.872
NP2	2782.2	933.5 ab	2.980
NP3	2681.4	850.3 b	3.153
NP4	2793.5	914.5 ab	3.055
NP5	2695.4	841.0 b	3.205
NP6	2749.1	884.8 ab	3.107
CV(%)	3.97	7.34	5.92

[1]Means followed by different letters in the same column are different by the Student-Newman-Keuls test (P<0.05).[2]NP1 = 3 feeds (Rostagno *et al*., 2000); NP2 = 5 feeds (Rostagno *et al*., 2000); NP3 = 28 feeds (Rostagno *et al*., 2000); NP4 = 28 feeds (92.5% of the mathematical model); NP5 = 28 feeds (100% of the mathematical model); NP6 = 28 feeds (107.5% of the mathematical model).CV (coefficient of variation).

Table 14 - Effect of the nutritional plans on the performance of 43- to 56-day-old female Ross broilers[1].

Nutritional Plan[2]	Feed intake (g)	Weight gain (g)	Feed conversion ratio
NP7	2502.0	743.8	3.364 ab
NP8	2515.8	762.7	3.299 a
NP9	2541.6	744.0	3.416 ab
NP10	2516.3	688.9	3.653 b
NP11	2537.3	737.8	3.439 ab
NP12	2533.4	727.0	3.485 ab
CV(%)	3.97	7.34	5.92

[1]Means followed by different letters in the same column are different by the Student-Newman-Keuls test (P<0.05).[2]NP7 = 3 feeds (Rostagno *et al.*, 2000); NP8 = 5 feeds (Rostagno *et al.*, 2000); NP9 = 28 feeds (Rostagno*et al.*, 2000); NP10 = 28 feeds (92.5% of the mathematical model); NP11 = 28 feeds (100% of the mathematical model); NP12 = 28 feeds (107.5% of the mathematical model).CV (coefficient of variation).

all the experimental diets and did not reach the requirements for maximum weight gain, as there were no statistical differences in feed intake.

The observed similarities in male feed intake and feed conversion ratio among treatments are consistent with the findings of Pope *et al*. (2001), Pope & Emmert (2002), and Warren & Emmert (2000), but disagree as to weight gain.

Tables 15 and 16 show the results of the performance 22- to 56-day-old male and female broilers, respectively, as a function of nutritional plan

There was no significant effect of the nutritional plans on feed intake, weight gain, or feed conversion ratio of male and female broilers during the studied period.

The absence of response to the different nutritional plans shows that, during this phase, the multiple-phase feeding programs, represented by plans NP3 to NP6 for males and NP9 to NP12 to females, do not impair bird performance.

Tables 17 and 18 show the results of the performance 1- to 42-day-old male and female broilers, respectively, as a function of nutritional plan.

The tested nutritional plans significantly influenced male livability and production factor and female feed conversion ratio. Male and female feed intake and weight gain, male feed conversion ratio, and female livability and production factor were not affected by the nutritional plans.

NP1 resulted in the lowest livability and production factor as compared to the other nutritional plans, which were not different from each other. The lowest production factor is exclusively due to the low livability, as the other parameters were not statistically different in males.

Table 15 - Effect of the nutritional plans on the performance of 22- to 56-day-old male Ross broilers[1].

Nutritional Plan[2]	Feed intake (g)	Weight gain (g)	Feed conversion ratio
NP1	6273.7	2612.5	2.401
NP2	6350.0	2572.7	2.468
NP3	6218.3	2480.7	2.507
NP4	6301.1	2559.4	2.462
NP5	6180.2	2489.0	2.483
NP6	6244.1	2522.0	2.476
CV(%)	2.98	3.42	2.64

[1](P>0.05).[2]NP1 = 3 feeds (Rostagno *et al.*, 2000); NP2 = 5 feeds (Rostagno *et al.*, 2000); NP3 = 28 feeds (Rostagno *et al.*, 2000); NP4 = 28 feeds (92.5% of the mathematical model); NP5 = 28 feeds (100% of the mathematical model); NP6 = 28 feeds (107.5% of the mathematical model).CV (coefficient of variation).

Table 16 - Effect of the nutritional plans on the performance of 22- to 56-day-old male Ross broilers[1].

Nutritional Plan[2]	Feed intake (g)	Weight gain (g)	Feed conversion ratio
NP7	5546.3	2061.8	2.690
NP8	5612.6	2123.6	2.643
NP9	5590.0	2089.8	2.675
NP10	5563.8	2015.3	2.761
NP11	5601.5	2070.6	2.705
NP12	5569.7	2090.9	2.664
CV(%)	2.98	3.42	2.64

[1](P>0.05).[2]NP7 = 3 feeds (Rostagno *et al.*, 2000); NP8 = 5 feeds (Rostagno *et al.*, 2000); NP9 = 28 feeds (Rostagno *et al.*, 2000); NP10 = 28 feeds (92.5% of the mathematical model); NP11 = 28 feeds (100% of the mathematical model); NP12 = 28 feeds (107.5% of the mathematical model).CV (coefficient of variation).

Table 17 - Effect of the nutritional plans on the performance of 1- to 42-day-old male Ross broilers[1].

Nutritional plan[2]	Feed intake (g)	Weight gain (g)	Feed conversion ratio	Livability(%)	Production factor
NP1	4708.4	2413.5	1.951	91.67 b	274.2 b
NP2	4834.5	2460.1	1.965	98.33 a	293.1 a
NP3	4758.3	2465.4	1.930	99.17 a	301.7 a
NP4	4690.5	2437.3	1.924	98.33 a	296.7 a
NP5	4683.0	2447.8	1.913	98.33 a	299.9 a
NP6	4713.3	2465.1	1.912	96.67 a	296.5 a
CV(%)	2.84	2.73	1.79	3.15	4.77

[1]Means followed by different letters in the same column are different by the Student-Newman-Keuls test (P<0.05). [2]NP1 = 3 feeds (Rostagno *et al*., 2000); NP2 = 5 feeds (Rostagno *et al*., 2000); NP3 = 28 feeds (Rostagno *et al*., 2000); NP4 = 28 feeds (92.5% of the mathematical model); NP5 = 28 feeds (100% of the mathematical model); NP6 = 28 feeds (107.5% of the mathematical model). CV (coefficient of variation).

Table 18 - Effect of the nutritional plans on the performance of 1- to 42-day-old female Ross broilers[1].

Nutritional plan[2]	Feed intake (g)	Weight gain (g)	Feed conversion ratio	Livability(%)	Production factor
NP7	4294.6	2066.8	2.078 b	98.15	232.5
NP8	4328.6	2107.3	2.054 b	97.22	237.3
NP9	4191.6	2090.9	2.005 a	100.00	248.4
NP10	4196.2	2090.9	2.007 a	100.00	248.1
NP11	4231.6	2116.7	1.999 a	98.15	247.4
NP12	4178.1	2116.9	1.974 a	98.15	250.7
CV(%)	2.84	2.73	1.79	3.15	4.77

[1]Means followed by different letters in the same column are different by the Student-Newman-Keuls test (P<0.05). [2]NP7 = 3 feeds (Rostagno *et al*., 2000); NP8 = 5 feeds (Rostagno et al., 2000); NP9 = 28 feeds (Rostagno *et al*., 2000); NP10 = 28 feeds (92.5% of the mathematical model); NP11 = 28 feeds (100% of the mathematical model); NP12 = 28 feeds (107.5% of the mathematical model). CV (coefficient of variation).

In females, the feed conversion ratios resulting from NP9, NP10, NP11, and NP12 were not different from each other, but were better than those obtained in NP7 and NP8 birds. This effect on feed conversion ratio was numerically observed in males, indicating that multiple-phase feeding programs (1 diet every 2 days) are similar to each other and promote better feed conversion ratios as compared to feeding programs with 3 and 5 feeds.

Despite reporting higher efficiency of multiple-phase feeding programs (MDFP) as compared to a 3-feed program during a similar experimental period, Loupe & Emmert (2000) found that MDFPs increased bird feed intake and weight gain, but had no influence on feed conversion ratio, which disagrees with the findings of the present study.

Tables 19 and 20 show the results of the performance 1- to 56-day-old male and female broilers, respectively, as a function of nutritional plan.

The tested nutritional plans significantly influenced only male production factor. Male and female feed intake, weight gain, feed conversion ratio, or livability and female production factor were not affected by the experimental treatments.

In males, the production factors of NP2 and NP4 birds were not different, but were higher as compared to NP5 birds. However, these three treatments were not different from the remaining nutritional plans.

Again, the production factor results suffered a strong influence of livability in each treatment.

The absence of effect of the different nutritional plans on male and female performance shows that 28-

Table 19 - Effect of the nutritional plans on the performance of 1- to 56-day-old male Ross broilers[1].

Nutritional plan[2]	Feed intake (g)	Weight gain (g)	Feed conversion ratio	Livability(%)	Production factor
NP1	7496.5	3402.5	2.203	89.17	245.9 ab
NP2	7616.7	3393.7	2.244	95.00	256.8 a
NP3	7439.7	3315.8	2.244	95.00	250.8 ab
NP4	7484.0	3351.9	2.233	95.00	254.7 a
NP5	7378.4	3288.8	2.243	90.00	235.4 b
NP6	7462.4	3350.0	2.228	90.83	244.0 ab
CV(%)	2.83	2.67	2.09	3.82	4.98

[1]Means followed by different letters in the same column are different by the Student-Newman-Keuls test (P<0.05). [2]NP1 = 3 feeds (Rostagno *et al*., 2000); NP2 = 5 feeds (Rostagno *et al*., 2000); NP3 = 28 feeds (Rostagno *et al*., 2000); NP4 = 28 feeds (92.5% of the mathematical model); NP5 = 28 feeds (100% of the mathematical model); NP6 = 28 feeds (107.5% of the mathematical model). CV (coefficient of variation).

Table 20 - Effect of the nutritional plans on the performance of 1- to 56-day-old female Ross broilers[1].

Nutritional plan[2]	Feed intake (g)	Weight gain (g)	Feed conversion ratio	Livability(%)	Production factor
NP7	6796.6	2810.6	2.418	98.15	203.8
NP8	6844.5	2869.9	2.385	96.30	206.9
NP9	6733.2	2834.9	2.375	100.00	213.2
NP10	6712.5	2779.8	2.415	100.00	205.6
NP11	6768.8	2854.5	2.371	94.44	203.0
NP12	6711.4	2843.9	2.360	97.22	209.2
CV(%)	2.83	2.67	2.09	3.82	4.98

[1](P>0.05). [2]NP7 = 3 feeds (Rostagno *et al*., 2000); NP8 = 5 feeds (Rostagno *et al*., 2000); NP9 = 28 feeds (Rostagno *et al*., 2000); NP10 = 28 feeds (92.5% of the mathematical model); NP11 = 28 feeds (100% of the mathematical model); NP12 = 28 feeds (107.5% of the mathematical model). CV (coefficient of variation).

diet feeding programs are similar to each other and promote similar performance as compared to 3- and 5-diet programs.

Considering that there were no significant differences in the performance of broilers submitted to the different nutritional plans and the average digestible lysine levels in the starter phase in plans NP3 and NP9, and in the grower and finisher phases of plans NP4 and NP10, it is possible to infer that in multiple-phase feeding programs, where diets are changed every two days, birds have lower lysine requirements, or promote better lysine utilization efficiency, and therefore, maximum performance. Based on the lysine levels of those plans, the equations were fit to: Y = -0.0079x + 1.2435 (R^2 = 0.981) for males and Y = -0.0084x + 1.1925 (R^2 = 0.978) for females, where "Y" is digestible lysine level (%) and "x" is average age in days. These equations are specific for multiple-phase feeding programs.

CONCLUSIONS

The technique of dilution can be used to produce a high number of diets; however, the tested 28-diet feeding programs were similar to each other, promoting the same performance as that produced by feeding programs that include three and five feeds.

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