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Productive and Economic Performance of Broiler Chickens Subjected to Different Nutritional Plans

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ABSTRACT

The objective of the study was to evaluate the effect of nutritional plans on the productive and economic performance of Hubbard Flex broiler chickens. A completely randomized experimental design was applied, consisting of five treatments. Treatments consisted of five different nutritional plans: a basal diet containing the nutrient and energy levels recommended by literature and designated reference diet; two diets containing 1.5% and 3% lower levels than the reference diet; and two diets containing 1.5% and 3% higher levels than the reference diet (-3%, -1.5%, reference plan, +1.5% and +3%). Feed intake (FI), body weight (BW), feed conversion rate (FCR), livability (L) and productive efficient index (PEI) were determined when broilers were 42 days old. Broilers were processed, and carcass and parts (breast fillet, leg, and wings) yields were determined. The economic viablility of the nutitional plans was evaluated as a function of feed cost/kg live and carcass weights, economic efficiency index (EEI), and cost index (CI). Feed intake and the feed conversion rate decreased as dietary nutrient and energy levels increased. Feed cost/kg live weight, economic efficiency index, and cost index cost increased as dietary nutrient and energy levels increased. Feed intake, feed conversion ratio, production efficiency index, and breast yield improved with increasing nutritional and energy levels. However, worse economic results were obtained with higher nutritional and energy levels.

INTRODUCTION

The improvement of performance parameters requires constant adjustment of the nutritional requirements of the modern broiler strains, in order to allow the expression of their full genetic potential. When adequately fed, broilers are efficient, producing the required carcass yield and quality at the lowest possible cost.

When evaluating the effect of dietary nutritional levels on broiler performance, no performance losses were observed by Aziz *et al.* (2011), when diluting dietary protein and energy, or by Widyaratne & Drew (2011), when reducing protein and digestible amino acid levels. This indicates that reducing dietary nutrient levels may yield significant performance and economic benefits. Leandro *et al.* (2003) observed that the dietary metabolizable energy and crude protein levels applied in different nutritional plans influenced the weight gain and the feed conversion ratio of both male and female Ross 308 broilers, as well as male breast yield, and emphasized the importance of studies to determine the best nutritional plan for each broiler strain.

Feed cost accounts for the greatest proportion of broiler production variable costs (Kamran *et al.*, 2008; Moosavi *et al.*, 2011), having a direct impact on farm productivity, and therefore, on its profitability. Production efficiency is significantly and negatively affected when feed nutritional levels are lower than the broilers' requirements. On the other hand, supplying diets with nutrient levels above the requirements improves live performance, but may result in economic losses due the higher cost of those diets.

Considering that the genetic line Hubbard Flex was recently introduced in Brazil, where climate, production conditions, and typical feedstuffs are different from those in the country of origin, its nutritional requirements under Brazilian conditions need to be established. According to Araujo *et al.* (2002), the nutritional recommendations established in genetic manuals do not always promote maximum live performance and profitability when applied in the Brazilian broiler production setting.

Therefore, the objective of this study was to evaluate the effects different nutritional plans relative to the recommendations on the live and economic performance of Hubbard Flex broilers reared during the summer in the southeast of Brazil.

MATERIAL AND METHODS

The experiment was carried out in the experimental broiler facilities of Gloria experimental farm of the Federal University of Uberlândia, state of Minas Gerais, Brazil, between March and April, 2013. The experimental procedures were approved by the Committee of Ethics of that university, under protocol CEUA/UFU 002/13.

In total, 1,700 (850 males and 850 females) one-day-old Hubbard Flex broilers, with 44-g average initial body weight, were housed in pens in a conventional poultry house until 42 days of age. A completely randomized experimental design, consisting of five treatments with 10 replicates of 34 birds per pen (17 males and 17 females) was applied.

Treatments consisted of five different nutritional plans: a basal diet containing the nutrient and energy levels recommended by Rostagno *et al.* (2011), and designated reference diet; two diets containing 1.5% and 3% lower levels than the reference diet; and two diets containing 1.5% and 3% higher levels than the reference diet (Tables 1 and 2).

Table 1 – Feedstuffs and calculated nutritional composition of the pre-starter and starter diets.

Ingredients (%)	Nutritional plans									
	Pre-starter					Starter				
	3% lower	1.5% lower	Reference	1.5% higher	3% higher	3% lower	1.5% lower	Reference	1.5% higher	3% higher
Sorghum	57.08	55.22	53.43	50.78	48.70	59.00	57.12	55.27	53.14	50.40
Soybean meal	35.58	36.38	37.18	38.77	39.77	32.95	33.75	34.57	35.66	37.27
Soybean oil	3.20	4.16	5.09	6.15	7.13	4.36	5.35	6.31	7.33	8.42
Dicalcium phosphate	1.80	1.80	1.85	1.90	1.90	1.44	1.44	1.50	1.55	1.55
Limestone	0.89	0.93	0.92	0.90	0.96	0.91	0.96	0.94	0.93	0.98
Salt	0.44	0.46	0.46	0.46	0.48	0.44	0.46	0.47	0.46	0.49
Premix starter*	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40
L-lysine	0.31	0.32	0.33	0.30	0.30	0.27	0.28	0.28	0.27	0.24
DL-methionine	0.19	0.21	0.22	0.22	0.23	0.14	0.15	0.17	0.17	0.17
L-threonine	0.11	0.12	0.12	0.12	0.13	0.09	0.09	0.09	0.09	0.08
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Nutritional levels										
ME (kcal/kg)	2,910	2,955	3,000	3,045	3,090	3,007	3,054	3,100	3,147	3,193
Crude protein (%)	22.06	22.30	22.52	22.86	23.19	20.91	21.13	21.37	21.69	22.00
Calcium (%)	0.89	0.91	0.92	0.93	0.95	0.81	0.83	0.84	0.85	0.86
Available P (%)	0.46	0.46	0.47	0.48	0.48	0.39	0.39	0.40	0.41	0.41
Sodium (%)	0.21	0.22	0.22	0.22	0.23	0.21	0.22	0.22	0.22	0.23
Dig. lysine (%)	1.28	1.30	1.32	1.34	1.36	1.18	1.20	1.22	1.24	1.26
Dig. methionine (%)	0.65	0.66	0.67	0.68	0.69	0.59	0.60	0.61	0.62	0.63
Dig. met+cys (%)	0.92	1.02	1.04	1.06	1.07	0.85	0.87	0.88	0.89	0.91
Dig. threonine (%)	0.83	0.85	0.86	0.87	0.88	0.77	0.78	0.79	0.80	0.81
Dig. tryptophan (%)	0.25	0.25	0.26	0.26	0.27	0.23	0.24	0.24	0.24	0.25
Dig. arginine (%)	1.36	1.38	1.40	1.42	1.44	1.28	1.30	1.32	1.34	1.36

*Premix starter (composition per kg product): vitamin A 1,600,000 IU; vitamin B1 600 mg; vitamin B12 20 mcg; vitamin B2 800 mg; vitamin B6 400 mg; vitamin D3 4,000 IU; vitamin E 30 mg; vitamin K 400 mg; zinc 12.60 g; copper 1,260 mg; selenium 80 mg; iron 10.50 g; iodine 252 mg; manganese 12.60 g; folic acid 140 mg; pantothenic acid 1,600 mg; zinc bacitracin 11 g; biotin 12 mg; choline 70 g; methionine 336.60 g; sodium monensin 22 g; niacin 6,000 mg.

Table 2 – Feedstuffs and calculated nutritional composition of the grower and finisher diets.

	Nutritional plans									
	Grower					Finisher				
Ingredients (%)	3% lower	1.5% lower	Reference	1.5% higher	3% higher	3% lower	1.5% lower	Reference	1.5% higher	3% higher
Sorghum	61.48	59.66	57.67	55.53	52.77	64.08	62.24	60.55	57.82	55.69
Soybean meal	29.64	30.44	31.38	32.45	34.10	27.24	28.04	28.67	30.29	31.31
Soybean oil	5.44	6.44	7.44	8.47	9.59	5.70	6.69	7.67	8.79	9.85
Dicalcium phosphate	1.20	1.26	1.28	1.31	1.30	1.00	1.00	1.05	1.06	1.11
Limestone	0.90	0.89	0.89	0.90	0.91	0.77	0.79	0.79	0.80	0.79
Salt	0.44	0.44	0.44	0.44	0.47	0.42	0.45	0.45	0.45	0.47
Premix grower*	0.40	0.40	0.40	0.40	0.40	-	-	-	-	-
Premix finisher**	-	-	-	-	-	0.30	0.30	0.30	0.30	0.30
L-lysine	0.28	0.26	0.26	0.26	0.22	0.26	0.25	0.26	0.23	0.22
DL-methionine	0.14	0.14	0.16	0.16	0.16	0.17	0.18	0.19	0.20	0.20
L-threonine	0.08	0.07	0.08	0.08	0.08	0.06	0.06	0.07	0.06	0.06
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Composition										
ME (kcal/kg)	3,104	3,152	3,200	3,248	3,296	3,153	3,201	3,250	3,299	3,348
Crude protein (%)	19.59	19.77	20.07	20.37	20.85	18.70	18.90	19.06	19.55	19.83
Calcium (%)	0.74	0.75	0.76	0.77	0.78	0.64	0.65	0.66	0.67	0.68
Avail. phosphorus (%)	0.34	0.34	0.35	0.36	0.36	0.30	0.31	0.31	0.31	0.32
Sodium (%)	0.20	0.210	0.210	0.210	0.220	0.20	0.21	0.21	0.21	0.22
Dig. lysine (%)	1.10	1.11	1.13	1.15	1.16	1.03	1.04	1.06	1.08	1.09
Dig. methionine (%)	0.55	0.56	0.57	0.58	0.59	0.51	0.52	0.53	0.54	0.55
Dig. met+cys (%)	0.80	0.81	0.82	0.83	0.84	0.75	0.76	0.77	0.78	0.79
Dig. threonine (%)	0.72	0.73	0.74	0.75	0.76	0.67	0.68	0.69	0.70	0.71
Dig. tryptophan (%)	0.21	0.22	0.22	0.22	0.23	0.20	0.21	0.21	0.21	0.22
Dig. arginine (%)	1.18	1.20	1.22	1.24	1.26	1.11	1.13	1.14	1.15	1.17

*Premix grower (composition per kg product): vitamin A 1,280,000 IU; vitamin B1 400 mg; vitamin B12 1,600 mcg; vitamin B2 720 mg; vitamin B6 320 mg; vitamin D3 3,500 IU; vitamin E 2.400 mg; vitamin K 300 mg; copper 1,200 mg; iron 10 g; iodine 240 mg; manganese 12 g; selenium 60 mg; zinc 12 g; folic acid 100 mg; pantothenic acid 1,600 mg; biotin 6 mg; choline 50 g; halquinol 6,000 mg; methionine 267.30 g; niacin 4,800 mg; salinomycin 13.20 g.

**Premix finisher (composition per kg do product): vitamin A 1,300,260 IU; vitamin B1 166 mg; vitamin B12 1,667 mcg; vitamin B2 666.80 mg; vitamin B6 200 mg; vitamin D3 4,000 IU; vitamin E 2,167.10 mg; vitamin K 333.40 mg; copper 2,000 mg; iron 16.60 g; iodine 400 mg; manganese 20 g; selenium 60.68 mg; zinc 20 g; folic acid 100 mg; pantothenic acid 1,333 mg; biotin 6.67 mg; choline 50 g; methyl 230 g; niacin 4,000 mg; virginiamycin 3,666 mg.

Diets were formulated according to a 4-phase feeding schedule: pre-starter (1-7 d), starter (8-21 d), grower (22-35 d), and finisher (36-42 d).

Cumulative performance was evaluated at 42 days of age. Birds and feed offer and residues were weekly weighed, and mortality was daily recorded. The following parameters were evaluated: average feed intake (FI), average body weight (BW), feed conversion ratio (CA), livability, and productive efficiency index (PEI). This index took into account body weight, livability, bird age, and feed conversion ratio, and was calculated according to the following equation:

$$\text{PEI (\%)} = \frac{\text{Body weight (kg) x livability (\%) x 100}}{\text{Age (days) x feed conversion ratio}}$$

At 42 days of age, 10 birds per treatment (five males and five females), with average live weight equal to the average weight (± 5%) of each treatment, were processed (stunned, bled, scalded, plucked, and eviscerated). Carcass yield (CY, %) was calculated as clean and eviscerated carcass weight relative to body weight at slaughter. Carcasses were then cut up, and parts yields (thigh+drumstick or leg, breast fillet, and wings) were calculated as part weight relative to carcass weight.

The economic viability of the applied nutritional plans was determined as feed cost relative to body weight (Yi) and relative to eviscerated carcass weight (Yi), according to the following equation proposed by Bellaver *et al.* (1985):

$$Y_i = \frac{Q_i \times P_i}{G_i}$$

where Yi is the feed cost per kg of body weight or eviscerated carcass weight of the ith treatment; Pi is the price per kg feed fed in the ith treatment; Qi is the amount of feed intake in the ith treatment; and Gi is the weight gain or carcass weight obtained in the i^{th} treatment.

Diet cost and feed intake were separately calculated for each feeding phase, and subsequently summed. The price of each dietary treatment took into account nutrient density. The feedstuff prices considered were those effective in the market of the region of Uberlândia, state of Minas Gerais, in March, 2013.

Subsequently, the economic efficiency index (EEI) and the cost index (CI), proposed by Fialho *et al.* (1992), as follows:

$$EE_i = \frac{LC_a \text{ x } 100}{CT_{ai}}$$

and

$$CI = \frac{CT_{ai} \text{ x } 100}{LC_a}$$

where MC_a is the lowest feed cost per kg body weight or eviscerated carcass weight among treatments and CT_{ai} is the cost of the i^{th} treatment.

Data were checked for residue normality, and then submitted to analysis of variance at 5% significance level. Nutritional plan data were submitted to analysis of regression. Statistical analyses were performed using SAS 9.3 (SAS, 2011).

RESULTS AND DISCUSSION

The performance results obtained from one to 42 days of age are shown in Table 3. Feed intake and feed conversion ratio linearly decreased as dietary nutrient and energy levels increased. Body weight presented a cubic response to nutritional plan, with the lowest body weight obtained at +0.106% nutritional level.

The treatments did not influence (p>0.05) livability. Production efficiency index linearly improved as dietary nutrient and energy density increased, which may have been due to the linear reduction in feed conversion ratio.

Reginatto *et al.* (2000), Mendes *et al.* (2004), and Dozier *et al.* (2006), evaluating different nutritional plans, also found a linear reduction in feed intake with increasing dietary energy levels. Waldroup *et al.* (1990) and Dozier *et al.* (2006) stated that dietary energy level controls the feed intake of broilers. Silva *et al.* (2001), Costa *et al.* (2001), and Kamran *et al.* (2008) observed a linear reduction in feed intake and feed conversion ratio with increasing dietary crude protein levels.

The manipulation of dietary nutrient density levels may be an alternative to supply the nutritional requirements of broilers, while minimizing performance losses resulting from reduced feed intake, as typically occurs in hot climates. In the present experiment, dietary energy level was increased with the inclusion of oil, which promotes low heat increment, and therefore, better dietary energy:protein ratio, resulting in high protein deposition and consequent better feed conversion ratio. This result corroborates with Leandro *et al.* (2003), Mendes *et al.* (2004), and Sakomura *et al.* (2004), who reported that feed conversion ratio improved as dietary ME levels increased. On the other hand, Lima *et al.* (2008) did not find any effect of dietary energy and amino acid levels on the feed conversion ratio of either male or female broilers between 1-40 or 1-45 days of age. Relative to dietary amino acid content, Kidd *et al.* (2005) observed better feed conversion ratio when supplying higher amino acid levels.

Table 3 – Feed intake (FI), body weight (BW), feed conversion (FCR), livability (LIV), and productive efficiency index (PEI) of 42-d-old Hubbard Flex broilers submitted to different nutritional plans.

Treatments		FI (kg)	BW (kg)	FCR (kg/kg)	LIV (%)	PEI (%)
Plan -3%		4.750	2.853	1.670	95.90	391.31
Plan -1.5%		4.670	2.892	1.628	97.39	415.22
Reference plan		4.574	2.860	1.605	97.71	416.54
Plan +1.5%		4.381	2.781	1.589	98.04	412.62
Plan +3%		4.300	2.820	1.551	97.32	428.90
CV (%)		4.64	2.72	3.03	2.98	5.58
p value	Linear	<0.0001[1]	0.2600	<0.0001[3]	0.7314	0.0013[4]
	Quadratic	0.5094	0.5894	0.6664	0.2153	0.4346
	Cubic	0.3191	0.0139[2]	0.1713	0.9692	0.0621

[1] $y = 4.5346-0.07891x$ ($R^2 = 0.9756$)

[2] $y=2.87499-0.04729x-0.00147x^2+0.00464x^3$ ($R^2=0.9603$)

[3] $y=1.60859-0.01859x$ ($R^2=0.976$)

[4] $y=412.79935+4.95579x$ ($R^2=0.7111$)

CV = coefficient of variation

Similarly to the results of the present study, Silva *et al.* (2001) did not find any influence of different dietary energy levels and ME:CP ratios on broiler mortality.

There was no interaction between sex and nutritional plans for carcass yield or breast and wing yields. However, a significant interaction between these factors was observed for leg yield (Table 4). The regression equation for females showed that the lowest leg yield was obtained at a -0.278% nutritional plan, whereas the regression equation for males indicated the highest leg yield at a nutritional plan of +0.233%.

Nutritional plans did not affect carcass, breast meat, or wing yields.

The obtained results are consistent with the reports of Leandro *et al.* (2003) and Kamran *et al.* (2008), who did not find any carcass yield differences in broilers submitted to different nutritional plans, i.e., fed diets with different energy and protein levels. On the other hand, Sabino *et al.* (2004) found a linear effect of increasing CP levels on carcass yield. Such divergent results may be attributed to differences among broiler strains, dietary nutritional levels and nutrient balances applied in the experiments.

Higher protein intake results in higher breast yield, as shown by Costa *et al.* (2001), who observed a linear increase in breast yield in broilers fed diets containing 17.50 to 19.50% CP. However, this effect was not observed in the present experiment, possibly due to the physiology of the evaluated broiler strain.

Antunes *et al.* (2012), evaluating the effects of three dietary energy levels on the carcass yield of two broiler strains, did not find wing yield or breast yield (with or without the skin and bones) differences; however, lower leg yield was obtained when broilers were fed the intermediate energy level.

Table 4 also shows the effect of sex ($p<0.05$) on carcass yield, with males presenting better results, independently of energy levels, whereas parts yields were not different between sexes. Female broilers accumulate more body fat, which compromises their weight gain and therefore, their carcass yield.

Table 5 shows the results of feed cost/kg body weight, economic efficiency index, and cost index, which were used for the analysis of the economic viability of the different nutritional plans. Feed cost/kg body weight was linearly affected by the nutritional plans, and is represented by the equation $y = 0.0065x + 1.1069$ ($R^2 = 0.8765$), showing that feed cost increased as dietary nutrient levels increased.

The best economic efficiency and cost indexes were obtained with the -3% and -1.5% plans. Therefore, it does not seem to be economically viable to increase nutrient and energy levels in the diet of Hubbard Flex broilers. However, this depends on the market price of soybean meal and soybean oil at the time of feed formulation, as these were the feedstuffs which levels were most increased in the diets and that most affected the economic indices.

Table 4 – Carcass yield (CY), leg yield (LY), breast fillet yield (BFY), and wing yield (WY) of 42-d-old male and female broilers submitted to different nutritional plans.

			CY	LY	BFY	WY
	-3%		84.01	22.34	20.48	8.29
	-1.5%		83.85	22.55	19.42	8.28
Nutritional plan	0		83.83	22.02	20.50	8.17
	1.5%		83.28	22.39	18.92	8.07
	3%		84.16	22.30	19.98	8.58
Sex	Female		83.50	21.78	19.80	8.35
	Male		84.16	22.86	19.92	8.21
	CV (%)		1.23	4.69	7.87	6.32
p-value	Nutritional plan	Linear	0.7846	0.9478	0.2948	0.4552
		Quadratic	0.2182	0.8911	0.3523	0.0759
		Cubic	0.2008	0.9750	0.7274	0.1501
	Sex		0.0231	<0.0001	0.7789	0.3153
	Interaction		0.6055	0.0179	0.0924	0.0891
	Female		-	Cubic[1]	-	-
	Male		-	Cubic[2]	-	-

[1] $y = 0.0696x^3+0.058x^2-0.6499x+21.523$ ($R^2 = 0.924$)

[2] $y = -0.0556x^3-0.0389x^2+0.5101x+23.036$ ($R^2 = 0.8426$)

CV = coefficient of variation

Table 5 – Feed cost per kg body weight (FC/kg BW), economic efficiency index (EEI), and cost index (CI) obtained for 42-d-old Hubbard Flex broilers submitted to different nutritional plans.

Treatments		FC/kg BW	EEI	CI
Plan -3%		1.09	100.00	100.00
Plan -1.5%		1.09	100.00	100.00
Reference plan		1.10	99.09	100.91
Plan +1.5%		1.12	97.32	102.75
Plan +3%		1.12	97.32	102.75
CV (%)		2.45		
p-value	Linear	0.0047[1]		
	Quadratic	0.6187		
	Cubic	0.1729		

[1]$y = 0.0065x+1.1069$ ($R^2 = 0.8765$)

CV = coefficient of variation

Table 6 shows the results of the economic viability analysis relative to eviscerated carcass. Feed cost/kg eviscerated carcass was not influenced by the nutritional plans. The best economic efficiency and cost indexes were obtained with the -3% plan, followed by +1.5 and + 3% plans. Therefore, the nutritional plan to be applied depends on the market price of feedstuffs, as mentioned above.

Table 6 – Feed cost per kg eviscerated carcass (FC/kg eviscerated carcass), economic efficiency index (EEI), and cost index (CI) obtained for 42-d-old Hubbard Flex broilers submitted to different nutritional plans.

Treatments		FC/kg carcass	EEI	CI
Plan -3%		1.32	100.00	100.00
Plan -1.5%		1.35	97.78	102.27
Reference plan		1.35	97.78	102.27
Plan +1.5%		1.33	99.25	100.76
Plan +3%		1.33	99.25	100.76
CV (%)		2.76		
p-value	Linear	0.2704		
	Quadratic	0.0889		
	Cubic	0.2355		

CV = coefficient of variation

CONCLUSIONS

Feed intake, feed conversion ratio, production efficiency index, and breast yield improved with increasing nutritional and energy levels. However, worse economic results were obtained with higher nutritional and energy levels. Therefore, the choice of the nutritional plan to be applied depends on the market price of feedstuffs at the time of feed formulation.

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