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Effects of dietary crude protein on slaughter yield of selected broiler stocks

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Abstract. The objective of this paper was to determine the differences in yield and body composition between a commercial strain (COM) and a weakly selected strain (FR) of broilers at two slaughter ages on diets differing in protein content. There were 306 males reared on litter floor pens, fed ad libitum, and randomly assigned to 16 pens in a 2 × 2 factorial design with 4 repetitions. The diets were HP (high protein): 20.5% protein to 6 weeks of age and 16.9% from then on; LP (low protein): 16.9% protein all the time. At 50 and 71 days, four broilers from each pen were taken at random, fasted, killed, slaughtered and the following weights were recorded: live weight, eviscerated carcass, abdominal fat, feathers, blood, small intestine, large intestine, gizzard, proventriculus, liver, breast, thighs and heart. Analyses of variance for traits and for their proportions to live weight were done. The model included genotype, diet, genotype × diet and replicate. The genotypes differed in live weight and growth patterns, COM showing a higher proportion of commercial cut weight and FR a higher digestive organ and relative feather weight at older ages. The low protein diet affected COM genotypes more than FR genotypes, probably because there was a difference in protein requirements.

Key words: broiler strain, dietary protein, selection level, slaughter yield.

Introduction

The body weight of a broiler at any point in lifetime is a function of cumulative growth of component parts, each having a pattern which may be influenced by genetics, diet and other environmental factors (LIU et al. 1995).

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Different poultry genotypes show a different adaptation to suboptimal nutritional conditions (ROBBINS 1981, CAHANER et al. 1987). This may be due to polymorphism in loci which affect adaptation to various stressors. Weakly selected genotypes with a lower performance in the optimal environment are usually less affected by suboptimal conditions than commercial strains strongly selected in optimal environments (CAHANER 1990).

The growth curve for a certain market demand is a variable that should be considered as another environmental factor (CAHANER 1990). Commercial poultry selection was done for weight gain up to 40 days of age (PINGEL 1994) while there is an increasing demand for more „natural products" which requires broilers over 75 days of age (VELEZ 1995).

The difference in relative carcass composition and organ weight between strains determines the nutritional efficiency and performance of the strains, because energy cost for deposition of a gram of fatty tissue is four times that for a gram of lean (SOLLER, EITAN 1984), and organ weight relative to body weight decreases as the rate of growth increases (KATANBAF et al. 1989, DUNNINGTON, SIEGEL 1990, NIR et al. 1993, SUSBILLA et al. 1994). Generally, the relative weight of the "supply" organs (heart, lungs, liver and gastrointestinal tract) decreases while the relative weight of the "demand" organs (muscles, feathers and abdominal fat) increases. The genetic factors influencing the development of the supply organs which support the functions of the demand organs can be modified by non-genetic management practices (SUSBILLA et al. 1994).

As a way of showing the changes in characters associated with production brought about by selection, an evaluation of intensely and weakly selected strains was done. Two levels of protein were chosen in order to determine their effects on the traits and the slaughter ages of 50 and 75 days are the usual ages at wich COM and FR poultry, respectively, are slaughtered in our country.

The objective of this paper was to compare yield and body composition of a commercial and a weakly selected broiler strain (free range system), at two slaughter ages in two different feeding regimes.

Material and methods

The free range (FR) chicks were obtained from a cross of closed old flocks of Cornish and White Rock chickens. A commercial broiler firm provided commercial type chicks (COM) belonging to the Ross strain. In all, 306 males were reared in litter floor pens of 2.5 m^2 with feed and water provided ad libitum. The genotypes and diets were randomly assigned to 16 pens in a 2 × 2 factorial design with 4 repetitions. The birds were grown in spring in one open-sided poultry house following the conventional management recommendations for 71 days. A lighting program of 1 h dark : 23 h light was used. The temperature was maintained at approximately 35°C for the first week, then decreased gradually to 22°C at the age

of 28 days. The birds were fed two isoenergetic diets. The HP (high protein) diet contained: 20.5% protein up to the 6th week of age and 16.9% protein from then on. The LP (low protein) diet contained 16.9% protein all the time. Since 20.5% protein is about the recommended level, 16.9% can be considered as a low protein diet for the first period. At the age of 50 and 71 days, 64 broilers taken at random from all pens (4 from each), were fasted over-night, killed, bled, slaughtered and the following weights were recorded: live weight (LW), eviscerated carcass (CW), abdominal fat (AF), feathers (FE), blood (BL), small intestine (SI), large intestine (LI), gizzard (GI), proventriculus (PRO), liver (LV), breast (BR), thighs (TH) and heart (HE). FE was calculated as the difference between dead body weight and defeathered body weight, and BL as the difference between LW and dead body weight. Analyses of variance for the given traits at each slaughter age and their proportions to LW were done with a model that included genotype, diet, genotype × diet interaction, and replicate nested within the interaction (NESTER et al. 1985). Variance among repetitions was the experimental error used to test ge-

Table 1. Ingredients and chemical composition of the experimental high protein (HP) and low protein (LP) diets (%)

	Diet	
	HP	LP
Ingredients		
Maize	59.79	65.53
Soybean meal	24.58	15.03
Peanut meal	8.65	4.98
Meat meal	6.26	6.50
Wheat bran	–	7.30
NaCl	0.17	0.17
Methionine DL	0.17	0.11
Lysine	0.13	0.12
Choline	0.07	0.07
Vitamin and mineral mix	0.10	0.10
Coccidiostatics	0.05	0.05
Chemical composition[1]		
Dry matter	87.9	88.7
Crude protein	20.5	16.9
Crude fibre	4.3	4.5
Ether extract	4.4	4.3
Ash	6.4	5.9

[1] ASSOCIATION OF OFFICIAL ANALYTICAL CHEMISTS. (1980). Official Methods of Analysis of the Association of Analytical Chemists. 13th ed. Association of Official Analytical Chemists, Washington, DC.

notype, diet and interaction effects; variance among birds was the sampling error. Another analysis of variance with the data of both slaughter ages was done including dates and the corresponding interactions in the model besides the effects included in the analysis for a single slaughter age. Comparison of means was made using the Bonferroni test (MILLER 1981). Phenotypic correlations between traits were also estimated. GLM and CANCORR procedures of SAS (SAS Institute1985) were used for all analyses.

Results

Slaughter age of 50 days

Results in Table 2 indicate that cuts, digestive organs, blood and feather weights of COM were heavier than those of FR ($P < 0.01$). Cuts, digestive organs, blood and feathers of poultry in the HP diet were heavier than those in the LP diet ($P < 0.05$). Differences in LV and HE were the only ones that did not reach statistical significance ($P > 0.05$). Genotype × diet interactions were not statistically significant ($P > 0.05$), except for TH. Differences in TH between diets were larger for COM than for FR chicks ($P < 0.05$).

Results in Table 3 indicate higher proportions of CW, BR and TH relative to live weight, for COM than for FR, and for HP than for LP ($P < 0.05$). By contrast, SI, PRO, GI and LI relative weights were heavier for FR than for COM ($P < 0.05$), but differences in AF, HE and LV relative weights did not reach statistical significance ($P > 0.05$). Differences between the diets were statistically significant ($P < 0.05$), except for SI ($P > 0.05$). Differences between the genotypes and diets, as well as the interaction, were not significant for relative weight of BL and FE ($P > 0.05$).

Phenotypic correlations among live weight, cuts, abdominal fat, digestive organs, blood and feathers were high and positive (Table 4). Relative weight of digestive organs was negatively correlated with live weight cuts and the weight of feathers.

Slaughter age of 71 days

The pattern of differences in absolute weight between the genotypes (Table 2) was very similar to that of broilers slaughtered at 50 days. Differences between the diets for BL, FE, PRO, GI, LV and HE weights that have been significant at 50 days, were not statistically significant ($P > 0.05$) any more. Relative weights of CW, BR and TH (Table 3) were higher for COM than for FR, but digestive organs (PRO, GI and LI) and FE were relatively higher for FR ($P < 0.05$). CW and BR relative weights were higher for HP than for LP ($P < 0.05$). Relative weights of all the other traits in the HP diet were similar or lower than those in the LP diet, but differences between the diets were statistically significant for TH, PRO, GI and

Table 2. Influence of levels of protein (high protein HP and low protein LP diets) on body composition in relation to live weight and absolute body composition of commercial (COM) and free range (FR) male broilers at two slaughter ages (50 and 71 days) – least square means ± standard errors

Genotype					Diet				Statistical analysis					
Slaughter age	50		71		50		71		genotype		diet		interaction	
	COM	FR	COM	FR	HP	LP	HP	LP	50	71	50	71	50	71
LW	2445.3±49.9	1455.2±49.9	3743.9±58.8	2494.8±57.7	2252.4±49.9	1647.9±49.9	3375.8±60.0	2862.9±56.5	**	**	**	**	NS	NS
CW	1606.2±34.6	905.9±33.9	2530.9±43.0	1581.5±42.1	1475.7±33.9	1036.3±34.6	2244.4±43.8	1867.9±41.3	**	**	**	**	NS	*
BR	457.3±11.9	233.3±11.9	747.8±15.9	432.6±15.5	411.6±11.9	269.1±11.9	658.3±16.2	522.1±15.2	**	**	**	**	NS	**
TH	290.5±7.3	162.7±7.3	430.9±7.2	274.5±7.0	268.3±7.3	184.9±7.3	378.5±7.3	326.9±6.9	**	**	**	**	*	NS
BL	81.8±3.2	52.9±3.3	108.2±4.2	81.2±4.1	75.7±3.3	59.1±3.2	94.4±4.3	95.0±4.0	**	**	**	NS	NS	NS
FE	140±5.3	95.3±5.4	245.3±7.7	201.5±7.6	140.5±5.4	95.5±5.3	233.6±7.9	213.2±7.4	**	**	**	NS	NS	NS
PRO	8.3±0.2	6.3±0.2	10.7±0.4	8.3±0.4	7.8±0.2	6.7±0.2	9.4±0.5	9.6±0.4	**	**	*	NS	NS	NS
GI	49.1±1.4	43.0±1.4	57.1±2.4	56.5±2.4	51.0±1.4	41.1±1.4	58.1±2.4	55.5±2.3	**	NS	**	NS	NS	NS
LI	74.1±1.5	49.7±1.5	90.6±2.0	66.3±1.9	66.1±1.5	57.7±1.5	84.2±2.0	72.7±1.9	**	**	*	*	NS	NS
SI	16.9±0.5	12.4±0.5	23.6±1.0	18.0±1.0	16.5±0.5	12.8±0.5	22.2±1.1	19.5±1.0	**	**	**	*	NS	NS
LV	41.9±0.9	25.5±0.9	52.8±1.0	36.0±1.0	35.8±0.9	31.7±0.9	46.6±1.0	42.3±1.0	**	**	NS	NS	NS	NS
HE	15.4±0.4	9.8±0.4	19.7±0.6	12.9±0.6	13.3±0.4	11.9±0.4	17.0±0.61	5.6±0.5	**	**	NS	NS	NS	NS
AF	56.6±2.2	31.1±2.2	99.7±4.0	70.2±3.9	55.3±2.2	32.4±2.2	106.8±4.0	63.1±3.8	**	*	**	**	NS	NS

* $P \leq 0.05$, ** $P \leq 0.01$, NS – $P > 0.05$.

LW – live weight; CW – eviscerated carcass, BR – breast, TH – thighs, BL – blood, FE – feathers, PRO – proventriculus, GI – gizzard, LI – large intestine, SI – small intestine, LV – liver, HE – heart, AF – abdominal fat.

Table 3. Influence of levels of protein (high protein HP and low protein LP diets) on body composition (relative to live weight) in commercial (COM) and free range (FR) male broilers at two slaughter ages (50 and 71 days) – least square means ± standard errors

Genotype					Diet				Statistical analysis					
Slaughter age	50		71		50		71		genotype		diet		interaction	
	COM	FR	COM	FR	HP	LP	HP	LP	50	71	50	71	50	71
CW	65.8±0.3	61.9±0.3	67.5±0.3	63.3±0.3	65.1±0.3	62.6±0.2	66.0±0.3	64.8±0.3	**	**	**	*	NS	NS
BR	18.4±0.2	15.1±0.2	19.9±0.3	17.3±0.3	17.8±0.2	15.7±0.2	19.2±0.3	18.0±0.3	**	**	**	*	NS	NS
TH	11.8±0.1	11.2±0.1	11.5±0.1	11.0±0.1	11.8±0.1	11.1±0.1	11.2±0.1	11.4±0.1	**	*	**	*	NS	NS
BL	3.4±0.1	3.7±0.1	3.0±0.2	3.3±0.2	3.1±0.1	3.6±0.1	2.9±0.2	3.3±0.2	NS	NS	NS	NS	NS	NS
FE	5.8±0.3	6.6±0.3	6.5±0.2	8.1±0.2	6.3±0.2	5.9±0.2	7.0±0.2	7.7±0.2	NS	**	NS	NS	NS	NS
PRO	0.3±0.03	0.4±0.01	0.3±0.01	0.3±0.01	0.4±0.01	0.4±0.01	0.3±0.01	0.3±0.01	**	**	**	NS	NS	NS
GI	2.1±0.1	3.0±0.1	1.5±0.1	2.3±0.1	2.4±0.1	2.7±0.1	1.8±0.1	2.0±0.1	**	**	*	NS	NS	NS
LI	3.1±0.1	3.5±0.1	2.4±0.1	2.7±0.1	3.0±0.1	3.6±0.1	2.5±0.1	2.6±0.1	**	*	**	NS	NS	NS
SI	0.7±0.03	0.9±0.03	0.6±0.03	0.7±0.03	0.8±0.03	0.8±0.03	0.7±0.03	0.7±0.03	**	NS	NS	NS	NS	NS
LV	1.7±0.04	1.8±0.04	1.4±0.03	1.5±0.03	1.6±0.04	2.0±0.04	1.4±0.03	1.5±0.03	NS	NS	**	*	NS	NS
HE	0.6±0.01	0.7±0.01	0.5±0.01	0.5±0.01	0.6±0.01	0.7±0.01	0.5±0.01	0.5±0.01	NS	NS	**	NS	NS	NS
AF	2.3±0.1	2.1±0.1	2.6±0.1	2.7±0.1	2.4±0.1	1.9±0.1	3.1±0.1	2.2±0.1	NS	NS	*	**	NS	NS

* $P \leq 0.05$, ** $P \leq 0.01$, NS – $P > 0.05$.

CW – eviscerated carcass, BR – breast, TH – thighs, BL – blood, FE – feathers, PRO – proventriculus, GI – gizzard, LI – large intestine, SI – small intestine, LV – liver, HE – heart, AF – abdominal fat.

Table 4. Phenotypic correlations between body component traits in absolute weight (g) and proportionally to live weight (g/g %) at 50 and 71(bold) days

Trait	LW		CW		BR		TH		PRO		GI		LI		SI		LV	
LW			0.99	**0.99**	0.96	**0.96**	0.97	**0.97**	0.73	**0.49**	0.62	**0.27**	0.91	**0.84**	0.74	**0.61**	0.86	**0.87**
AF	0.87	**0.71**	0.87	**0.68**	0.84	**0.66**	0.83	**0.62**	0.53	**0.20**	0.57	**0.21**	0.79	**0.72**	0.65	**0.43**	0.68	**0.51**
AF (%)	0.37	**0.24**	0.37	**0.19**	0.35	**0.18**	0.34	**0.13**	0.11	**–0.09**	0.29	**0.11**	0.32	**0.35**	0.33	**0.12**	0.21	**0.07**
FE	0.72	**0.66**	0.70	**0.63**	0.66	**0.58**	0.72	**0.63**	0.58	**0.27**	0.44	**0.34**	0.58	**0.52**	0.59	**0.50**	0.57	**0.51**
FE (%)	–0.18	**–0.45**	–0.20	**–0.47**	–0.21	**–0.47**	–0.15	**–0.46**	–0.09	**–0.31**	–0.11	**–0.02**	–0.27	**–0.41**	–0.06	**–0.20**	–0.22	**–0.42**
HE	0.86	**0.63**	0.85	**0.62**	0.82	**0.62**	0.84	**0.64**	0.70	**0.33**	0.53	**0.33**	0.86	**0.59**	0.69	**0.35**	0.88	**–0.58**
HE (%)	–0.45	**0.11**	–0.45	**0.09**	–0.44	**0.08**	–0.44	**0.13**	–0.25	**0.07**	–0.34	**0.20**	–0.30	**0.15**	–0.25	**0.00**	–0.18	**0.13**
			CW (%)		BR (%)		TH (%)		PRO (%)		GI (%)		LI (%)		SI (%)		LV (%)	
LW			0.83	**0.76**	0.82	**0.66**	0.52	**0.22**	–0.64	**–0.45**	–0.81	**–0.68**	–0.71	**–0.35**	–0.57	**–0.27**	–0.48	**–0.38**
AF			0.69	**0.33**	0.70	**0.36**	0.37	**–0.19**	–0.64	**–0.47**	–0.66	**–0.45**	–0.61	**–0.04**	–0.45	**–0.21**	–0.51	**–0.46**
AF (%)			0.25	**–0.12**	0.27	**–0.03**	0.02	**–0.43**	–0.40	**–0.34**	–0.29	**–0.12**	–0.29	**0.18**	–0.08	**–0.12**	–0.35	**–0.34**
FE			0.46	**0.34**	0.49	**0.28**	0.44	**0.03**	–0.43	**–0.39**	–0.57	**–0.34**	–0.62	**–0.30**	–0.34	**–0.08**	–0.44	**–0.38**
FE (%)			–0.34	**–0.55**	–0.27	**–0.45**	–0.01	**–0.24**	0.12	**0.09**	0.16	**0.38**	–0.03	**0.07**	0.19	**0.22**	–0.01	**0.06**
HE			0.68	**0.44**	0.68	**0.39**	0.43	**0.23**	–0.52	**–0.29**	–0.72	**–0.36**	–0.54	**–0.15**	–0.43	**–0.24**	–0.22	**–0.20**
HE (%)			–0.55	**0.02**	–0.33	**0.02**	–0.31	**0.12**	0.05	**–0.07**	0.33	**–0.00**	0.49	**0.03**	0.41	**–0.14**	0.58	**0.01**

LW – live weight, AF – abdominal fat, FE – feathers, HE – heart, CW – eviscerated carcass, BR – breast, TH – thighs, PRO – proventriculus, GI – gizzard, LI – large intestine, SI – small intestine, LV – liver.

LV ($P < 0.05$). Significant interactions were found for breast and carcass weight and were a consequence of the larger differences for COM than for FR ($P < 0.05$). No significant interactions were observed for relative weights ($P > 0.05$).

Phenotypic correlations followed the same pattern as at 50 days but were generally lower (Table 4). Correlations within COM were zero and negative (–0.39) for combinations of the relative TH with CW and BR, respectively. Correlations between relative AF and relative digestive organs were medium and negative, but within COM they were close to zero (0.06). HE was highly positively correlated with LW, CW and BR; they were lower for COM (0.50). Relative weight of HE was negatively correlated with the same traits but for the LP diet it was 0.40 and negative for HP (–0.20). Correlations between relative HE and relative CW and BR were close to zero, but when they were calculated within a diet, they were negative (–0.11, –0.38) for HP and positive for LP (0.15).

Both slaughters

Analysis of variance for the measured traits including both slaughters and date effect in the model, showed that the date × genotype interactions were significant for LW, BR and CW, and for relative HE ($P < 0.05$). LW, BR and CW of COM grew more from 50 to 71 days than those of FR, and relative HE was higher for FR at 50 days than for COM chicks while at 71 days they were similar. Date × diet interactions were found for TH, GI and AF and for relative weights of TH, LI, HE, LV and FE ($P < 0.05$). Relative TH and FE were higher at 71 than at 50 days for the LP, and larger differences were found for LP and FR in the other relative traits (results not shown).

Discussion

The results of this experiment confirm that live weight as well as weights of the different cuts and digestive organs are higher for the highly selected strain than for the less selected strain at a fixed age (MCCARTHY 1977, DUNNINGTON 1990, TRINIDADE et al. 1994). Cuts of COM were also heavier than those of FR when they were expressed as percentage of live weight. This is in agreement with TRINIDADE et al. (1994) and DUNNINGTON and SIEGEL (1996), who found similar results for breast weight, which is a trait selected for in commercial genotypes. WALL and ANTHONY (1995) did not find any differences in BR at the same LW between a commercial and a weakly selected breed. For relative CW and TH he reported the opposite, on the same weight basis. The interactions have been significant for live weight when all animals were included in the analysis for growth (MIQUEL et al. 1998). In this study, the interaction was significant at 50 days for thighs and at 71 days for CW and BR. This tendency showed that the difference between chicks was larger for COM than for FR for LW, CW, BR and TH at both dates and for AF at 71 days. No such tendency was observed for organ weights.

A low protein diet during the first period of growth, affected the weight of commercial cuts which were lower in relation to live weight than those of birds fed a high protein diet. This effect lasted until the end of the experiment, showing that the development of commercial cuts requires a certain amount of protein, as was reported by CAHANER et al. (1995) for breast. Weights of carcass and breast of COM were more affected by the lack of protein than the weight of FR, agreeing with results reported by CAHANER (1990), but not with results for breast reported by CAHANER et al. (1995). This different effect due to lack of protein between COM and FR may be a consequence of a difference in protein requirements. The difference in correlations between TH-CW and TH-BR within genotype supports this, and the difference in the traits selected (more breast in commercials) should explain it.

Since the LP diet is below the recommended requirements for growth during the first 42 days but agrees with them after this date, from the point of view of the requirements this treatment can be looked at as a low diet up to the 42 days but a high diet from this day on. It can be concluded then that since the differences between the diets are somewhat higher at 50 than at 71 days, the weight of carcass, breast and thigh showed compensatory growth. The relative weight of thighs is even higher for birds on the poorer diet, because they grew more than the total weight (Table 3). This different performance for thighs is also shown by the correlations: those between live weight and relative weights of carcass and breast were higher than the correlations with the relative weight of thighs, especially at 71 days (Table 4). LIU et al. (1995) reported similar dietary effects on weight.

Blood as well as FE remained proportional to live weight, except that feathers of the FR genotype at 71 days were heavier relative to live weight than those of COM, since COM usually were selected in more controlled environmental conditions than FR. Similar results have been obtained by DUNNINGTON and SIEGEL (1996) and MALLO et al. (1996), and this difference in relative weight of feathers may lead to a difference in maintenance energy requirements. There were no differences in feather weight of birds kept on the different diets (difference of 3.6% of protein in the starter diet). Similar results have been reported by CAHANER et al. (1987), GERAERT et al. (1993), MALLO et al. (1996) and LECLERCQ et al. (1994).

Relative weights of digestive organs of FR birds were higher than those of COM (opposite to what happened with the commercial cuts, as was stated earlier), showing that selection not only affected growth rate, but also the pattern of growth. Correlations among absolute weights were positive, but when relative weights were correlated, they were positive among commercial cuts, but negative between cuts and digestive organs, showing the difference in growth pattern for the traits. These results were in agreement with MALLO et al. (1996). DUNNINGTON and SIEGEL (1996) found that the relative weight of GI of weakly selected birds was higher than that of highly selected ones, but the reverse was observed for the relative weight of LI. DUNNINGTON (1990) and LIU et al. (1995) did not report any differences, and WALL and ANTHONY (1995) found the opposite at

the same weight comparison. Diet affected the growth of digestive organs (Table 2), but it affected total live weight more than organ weight, since organ relative to live weight is higher for the LP diet (Table 3). The weight of digestive organs showed compensatory growth and differences between the diets vanished at 71 days of age, except for small and large intestine weight, for which the effect of diet lasted until the end of the experiment at 71 days of age. These results showed a tendency for the proportions to be higher with a LP diet, in agreement with LIU et al. (1995) for LV, SUSBILLA et al. (1994) and MELO et al. (1996a), where the lower protein diet was due to a restricted regime. This supports the idea that an increase in the size of digestive organs improves the capacity of the chickens to ingest and digest food (CHERRY et al. 1978).

In the present experiment, although heavy weights were reached, no ascites was observed and no differences in relative HE were found. These results agree with those of WALL and ANTHONY (1995), done on the same weight basis, and disagree with LIU et al. (1995). The level of protein effect was important only at the age of 50 days and a compensatory effect may have equalled the proportions at 71 days. Correlation results suggest that the negative association of relative HE with LW was independent of selection level. Therefore, it was the increase in diet protein that changed the sign of the correlation from positive in the LP diet to negative in the HP diet, indicating that heart growth is limited.

The similar AF proportion between genotypes was in agreement with MALLO et al. (1996), TRINIDADE et al. (1994), PYM and SOLVYNS (1979) and PYM (1996), and in disagreement with LIU et al. (1995), DUNNINGTON and SIEGEL (1996), WALL and ANTHONY (1995), analysed on the same weight basis. Interactions were also reported and may explain the observed differences. CAHANER et al. (1995) reported no response in AF proportion in a low fat line, little response in a commercial line and a better response in a high fat line, when the protein level was increased.

The positive association of the "demand" organs AF with LW and its "muscular" components is commonly reported (CAHANER et al. 1985, VILLA et al. 1991,DUNNINGTON, SIEGEL 1996, MELO et al. 1996b, 1996c, 1997). The association between their relative weights is in disagreement with PYM and SOLVYNS (1979), who obtained a negative (–0.40) correlation between related traits, such as body fat and body protein. They also reported, within a line, a negative association for a high weight gain line and a positive one for a control line, opposite to our results. Their work was supported by CAHANER et al. (1995), who reported increases in relative AF when relative BR decreased. They also found line differences, a fat line being the one that showed the highest negative association.

The results of the experiment also showed that FR and LP broilers were poorer in feed conversion than the COM strain and HP, respectively, and that genotype × diet interaction was present for the trait (MIQUEL et al. 1998), when compared at the same age. Differences in feed conversion ratio between strains fed on diets differing in protein content were larger for commercial than for free range broilers.

This supports the findings of GERAERT et al. (1990, 1996), JORGENSEN et al. (1990) and PYM and SOLVYNS (1979), in the way that less body fat improves feed efficiency but can never explain completely the efficiency differences. Thus, in the present study the differences in feed conversion may be due to the digestive organ and the feather proportions, which contribute to the difference in energy maintenance, in agreement with KATANBAF et al. (1989) and NIR et al. (1993).

Conclusions

The studied genotypes differed in live weight and growth patterns since the commercial strain showed a higher proportion of commercial cut weight, and the free range type had higher relative digestive organ and feather weights at older ages. This different growth pattern may affect nutritional efficiency. Thus, differences in efficiency may be explained by other factors besides abdominal fat.

A low protein level affected commercial cuts more than live weight, while organ growth was less affected by protein level, showing a priority for their development. There was a tendency for commercial cuts of commercial broilers to be more affected by a low protein level than those of free range genotypes.

At a fixed age, there were no differences in percentage of abdominal fat between genotypes in both diets. The results indicate that if comparisons were made at the same weight, probably FR poultry would have more fat than commercial poultry.

It was found that traits associated with production were changed by selection. If selection was done on FR, it would be desirable to increase the proportion of commercial cuts and the nutritional efficiency, and to decrease abdominal fat without changing those traits which make them desirable for consumers of this kind of meat.

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