La composición corporal de gallinas ponedoras de 1 día hasta 72 semanas de edad alimentadas con diferentes programas nutricionales[1]

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Resumen: El objetivo del estudio fue comparar la composición corporal de gallinas ligeras y semipesadas sometidas a diferentes programas de alimentación desde el nacimiento hasta las 72 semanas de edad. Fueron utilizadas 828 aves Hy-line W36 y 828 Hy-Line Brown, alimentadas con 95%, 100% e 105% de sus exigencias nutricionales según el manual de la estirpe, distribuidas en un diseño experimental completamente al azar en una estructura factorial de 2 estirpes x 3 tratamientos, con 6 repeticiones y 46 aves por réplica. Dos aves por réplica fueron sacrificadas con el peso promedio de cada parcela el día 1 y en la semanas 4ª, 6ª, 8ª, 12ª, y cada 4 semanas hasta la semana 72ª de edad y sometidas a análisis de composición química (MS, EE, PB y cenizas). Los datos fueron analizados usando el procedimiento ANOVA del SAS y las medias fueron comparadas por el test de Tukey (5%). Las gallinas ligeras en la fase de cría tuvieron mayor deposición de grasa (p<0,05) que las aves semipesadas, y en la 6ª y 16ª semana de edad las aves ligeras también obtuvieron mayor deposición de proteína, demostrando un crecimiento inicial más precoz que las semipesadas. No hubo diferencias significativas (P<0,05) entre estirpes en la deposición de agua y de materia mineral en la fase de cría, ni en la deposición de materia mineral en la recría. En el período de postura no hubo diferencia (P>0,05) entre estirpes en la deposición de proteína. Sin embargo, después de 32 semanas de edad (madurez física) hubo efecto de la estirpe (P<0,05) para la deposición de materia orgánica y grasa, siendo mayores en las gallinas semipesadas. El peso corporal en las fases de cría, de recría y de puesta fue alcanzado según los requerimientos del manual 2013 de la estirpe por el programa nutricional que aportaba el 105% de las exigencias. El crecimiento y el peso corporal en la madurez deben ser considerados en conjunto en la definición del programa de alimentación ideal. Los datos actuales demuestran que el uso de 105% de las exigencias nutricionales para las dos estirpes mejora la velocidad de crecimiento y la deposición de los nutrientes.

Palabras – clave: crecimiento; deposición de nutrientes; requerimiento nutricional; ponedoras

Abstract: The goal of this research was to compare body composition of two lines of commercial layers, grown under different nutritional programs from hatch to 72-weeks old. They were used 828 Hy-line W36 and 828 Hy-Line Brown, fed 95%, 100% and 105% of their nutritional requirements according to the manual of the linage, distributed in a completely randomized design in a factorial structure 2 lines x 3 treatments with 6 replicates and 46 birds per replicate. Two birds with body weights that were the closest to the average of the experimental unit were euthanised. After a fast of 24 h (access to water was maintained) the birds were weighed and killed by cervical dislocation. At on day 1 and in the weeks 4th, 6th, 8th, 12th, and every 4 weeks until week 72 th of age and subjected to chemical composition analysis (water, fat, Crude protein and ash). Data were analyzed using the ANOVA procedure of SAS and means were compared by Tukey's test (5%). Hens line Hy-Line W36 in the growing stage had higher fat deposition ($p < 0.05$) than Hy – Line Brown, and in the 6th and 16th week of age the hens Hy-line W36 higher crude protein deposition, showing initial growth earlier than hens Brown. No significant differences ($P < 0.05$) between strains in the deposition of water and ash in the growing stage, or the deposition of ash in the rearing. In the laying period there was no difference ($P > 0.05$) between strains in protein deposition. However, in 32 weeks of age (physical maturity) was no effect of strain ($P < 0.05$) for the deposition of water and fat, being higher in Brown hens. Weight Body in the stages of breeding, rearing and commissioning was achieved according to the requirements of the 2013 Manual of strain by the nutritional program which provided 105% of the requirements. Growth and body weight at maturity must be considered together in defining the ideal feeding program. The present data demonstrate that the use of 105% of the nutritional requirements for the two strains improves the growth rate and deposition of nutrients.

Keywords: Growth; deposition of nutrient; nutritional requirements; hens

Introduction

Growth in laying hens through 18 weeks old is usually divided into three equal phases of six weeks each. Each phase is mainly characterized by a determining physiological aspect: bone and muscle formation (0 to 6 weeks), feathering (6 to 12 weeks), and formation of the reproductive tract (12 to 18 weeks), respectively (Neme *et. al.*, 2006). Rapid changes in poultry efficiency since the 1950s were mostly due to improved genetics (*e.g.*, broilers, Havenstein *et al.*, 2003) achieved through selection based on quantitative genetics procedures. Nutritional requirements of birds need to be constantly evaluated and updated in order to design biologically meaningful and economically efficient feeding programs. Accurate description of growth patterns and of meat and fat deposition should be pursued with the intent of achieving the above goals. Modern poultry industry requires the establishment of precise nutritional programs in order to realise the full genetic potential of the birds. Efficient deposition of protein, fat, and other nutrients in proper amounts should be aimed by taking into account the growth stage of the birds; especial attention should be paid to avoid excessive deposition of fat above the level that is physiologically required (Emmans, 1996) since fat is a nutritionally expensive tissue. Martin *et al.* (1994) noted that feeding programs and the monitoring of growth receive are less studied in pullets and hens than in broilers. Prediction of body composition at different stages of growth can be achieved with the use of growth curve models, allowing the tracking of changes in body composition both in its chemical and physical aspects. The goal of this research was to compare body composition of two lines of commercial layers, grown under different nutritional.

Materials and Methods

Birds from two genetic lines of high-yield laying hens (Hy-Line W36 and Hy-Line Brown) were used in this trial. With respect to adult body weight, the hens from the W36 line are considered light and those from the Brown line are considered heavy. Each line contributed 828 birds that were raised in metal cages from hatch to 72-weeks old. Chicks were individually weighed at day-old and 36 groups were formed with comparable initial average chick weight, distributed among the nutritional programs aiming at having similar average weights at the start of the trial. Each experimental unit consisted of

46 chicks. A 3x2 factorial arrangement was established in a completely randomized design. The factors were genetic line and nutritional program. The latter was based on the nutritional requirements set forth in the commercial guides of the breeding company (Hy-Line International, 2005a,b) and consisted of P1, 95% of the nutritional requirement, P2, 100% of the nutritional requirement, and P3, 105% of the nutritional requirement. Each combination of line and nutritional program had six replications. Protocols for bird care and utilization, including the exit method, were in compliance with the regulations set forth by the host institution and funding agencies and were strictly followed throughout the trial. Growers and pullets were vaccinated against bronchitis, infectious bursa disease, Newcastle disease, infectious coryza, and avian pox. When the pullets were moved to the laying houses they were given an Intermult 6® vaccine for multiple ailments; food and water were also made available at all times. Air temperature and humidity were recorded twice daily and remained between 24.0 – 29.8 ºC and 56 – 84 % (up to 6 weeks), 16.7 – 27.8 ºC and 37.7 – 76.6 % (through 17 weeks), and 19.1 – 28.3 ºC and 44.7 – 79.5 % (through 72 weeks), respectively. The lighting program was established according to the recommendations from the breeding company (Hy-Line International, 2005 - 2007a,b) for the completion of the standard nutritional program (P2-100% of requirements) and respectively the requirements of Hy-Line 2013a,b manual, showing that the study is within the recommended requirement for current recommendations (Hy-Line International, 2013a,b). For strains W36 and Brown respectively: *Initial phase (1 day - 6 weeks):* 20; 19 to 20% and 20; 18.25 until 20% crude protein (CP), 1.15; 1.07 to 1.15% and 1.10; 0.92 until 1.01% lysine (Lys); 1.00; 1.00% and 1.00; 1.00% calcium (Ca), 0.50; 0.50 until 0.49% and 0.45; 0.45 until 0.44% phosphorus (P), 0.75; 0.83% and 0.75; 0.72 until 0.77% methionine + cystine (Met + Cyt), 0.48; 0.47 until 0.51% and 0.48; 0.42 until 0.45% methionine (Met), 0.18; 0.18% sodium and 0.8; 0.17 until 0.18% (Na) and 2.950; 2977 until 3.087 and 2.950; 2.811 until 2.922 Kcal/kg metabolizable energy (ME); *Feed growth (7-9 weeks):* 18; 18% and 17.50; 17.50% crude protein (CP), lysine 0.96; 0.96% and 090; 0.82% (Lys), 1.00; 1.00% and 1.00; 1.00% calcium (Ca), 0.47; 0.47% and 0.43; 0.43% phosphorus (P), 0.70; 0.75% and 0.71; 0.66% methionine + cystine (Met + Cyt), 0.43; 044% and 0.41; 0.39% methionine (Met), 0.18; 0.18% and 0.18; 0.17% sodium (Na), 2.970; 2.977 until 3,087 and 2970; 2.789 until 2,900 Kcal/kg metabolizable energy (ME); *Feed growth (10 - 17 weeks)*: 16; 17% and 15.5; 16 until 16.5% crude protein (CP), lysine 0.85; 0.83 until 0.85% and 0.66; 0.67 until 0.72% (Lys), 1.40; 1.40 until 2.40% and 1.40; 1.40 until 2.50% calcium (Ca), 0.45; 0.45 until 0.48% and 0.42; 0.45 until 0.48% phosphorus (P), 0.66; 0.67 until 0.74% and 0.58; 0.59 until 0.65% methionine + cystine (Met + Cyt), 0.39; 0.38 until 0.41% and 0.32; 0.31 until 0.35% methionine (Met), 0.17; 0.18% and 0.18; 0.18% sodium (Na) and 3.000; 2.977 until 3.131 and 2.950; 2.712 until 2.933 Kcal/kg metabolizable energy (ME); *Laying feed initial until 32 weeks*: 17.50; 16.00% crude protein (CP), lysine 0.88; 0.88% (Lys), 3.65; 4.00% calcium (Ca), 0.50; 0.50% phosphorus (P), 0.82; 0.76% methionine + cystine (Met + Cyt), 0.48; 0.42% methionine (Met), 0.18; 018% sodium (Na) and 2.950; 2.844 until 2955 Kcal/kg metabolizable energy (ME); *Post-peak laying feed (33-44 weeks):* 15.50; 15.50% and 18; 17% crude protein (CP), lysine 0.82; 0.82 and 0.93%; 0.93% (Lys), 4.10; 4.20% and 4.00; 4.10% calcium (Ca), 0.46; 0.48% and 0.44; 0.46% phosphorus (P), 0.70; 0.71% and 0.76; 0.80% methionine + cystine (Met + Cyt), 0.40; 0.39% and 0.46; 0.45% methionine (Met), 0.17; 0.17% and 0.18; 0.18% sodium (Na) and 2.850; 2.844 until 2.944 and 2.950; 2.778 until 2.911 Kcal/kg metabolizable energy (ME); *Laying feed (45-58 weeks):* 15.25; 15.25% and 17.50; 16.75% crude protein (CP), lysine 0.78; 0.77% and 0.93; 0.92% (Lys), 4.25; 4.35% and 4.25; 4.40% calcium (Ca), 0.42; 0.46% and 0.40; 0.42% phosphorus (P), 0.56; 0.67% and 0.76; 0.81% methionine + cystine (Met + Cyt), 0.38; 0.37% and 0.46; 0.44% methionine (Met), 0.17; 0.18% and 0.18; 0.18% sodium (Na) and 2.850; 2.822 until 2.922 and 2.850; 2.734 until 2.867 Kcal/kg metabolizable energy (EM); *Laying feed (59-72 weeks):* 15.00; 15.00% and 14.54; 15.50% crude protein (CP), lysine 0.76; 0.76% and 0.75; 0.82% (Lys), 4.40; 4.50% and 4.34; 4.90% calcium (Ca), 0.38; 0.40% and 0.35; 0.37% phosphorus (P), 0.65; 0.64% and 0.72; 0.72% methionine + cystine (Met + Cyt), 0.37; 0.36% and 0.38; 0.39% methionine (Met), 0.17; 0.18% and 0.16; 0.18% sodium (Na), 2.800; 2.800 until 2.844 and 2.800; 2.558 until 2.873 Kcal/kg metabolizable energy (ME). The other programs had their requirements changed in 5% lower (P1-95% of requirements) and 5% above (P3-105% of requirements) in relation to nutritional requeriments P2 (100%). A detailed description of the facilities that housed the birds and husbandry procedures is reported in Santos (2008). The chemical composition of the carcases (dry matter, fat content as ethereal extract, crude protein, and ashes) was obtained based on the average data of two birds from each experimental unit. At on day 1 and in the

weeks 4th, 6th, 8th, 12th, and every 4 weeks until week 72 th of age and subjected to chemical composition analysis (water, fat, Crude protein and ash), two birds with body weights that were the closest to the average of the experimental unit were euthanised. After a fast of 24 h (access to water was maintained) the birds were weighed and killed by cervical dislocation. The birds were placed in an autoclave and then fully ground in an industrial grade blender. An aliquot from each pair of ground birds was dried in a convection oven at 65 ºC for 72 h and ground. Further chemical analyses were conducted to determine the ethereal extract, crude protein, and ashes content in each sample. The chemical composition of the carcases (water, fat content the ethereal extract, crude protein, and ashes) was obtained based on the SAS program (1998) and the differences between the averages established by Tukey test (α = 0.05).

Results and Discusion

Weight of deposited fat content was higher for the W36 line line than for the Brown line from day one to 16 weeks, similar to the pattern of protein deposition in brood and growout. After the 60th week the hens from the Brown line had higher fat deposition than hens from Line W36. There was no interaction between the effects of line and feeding regimen. In both lines there was an observed trend for the age at deposidet content of fat doesn't increase as the birds received a higher fraction of the recommended nutrition intake (Table 2). Brown birds had similar (P>0.05) weight ash content than W36; in each line the content of ashes was also similar despite the nutritional intake increased and this increase was steeper in the Brown birds. Brown birds had similar (P>0.05), weight ash content than W36, each line in the content of ashes was similar also despite the increased nutritional intake and this increase was steeper in the Brown birds. Water content deposition was higher for birds W36 line in the phase of grown initial than around 16ª weeks of age (P<0.05). There was no difference (P>0.05) in age at among nutritional programs also there was a trend for increased water content at 6ª weeks of age in the birds receiving the higher percentage of the recommended nutritional requirement (Table 2). In the conditions of this trial, nutritional program P1 provided inadequate nutrition to achieve the target body weights specified by the breeder company. Increasing the amount of feed intake by 5% proved a suitable adjustment to achieve the targets set by the breeder company. The birds were raised in environmental conditions that were slightly warmer than the prescribed ones for these lines, with an exception described ahead. This may have contributed to the finding that the additional 5% of feed intake provided by the nutritional plan P3 was necessary for the growers to attain their target body weights before puberty**.** The change in body composition was reflected in additional ashes, but not, fat, water and protein. Protein is not the preferred form of energy storage because its deposition is limited by the growth potential of the birds. Fat deposition, however is not limited. This developmental limitation has also evolutionary importance since lipid reserves are the preferred stored tissue to be mobilised; protein will only be used as an energy source after the amounts of stored fat and glycogen are close to depletion (Blem, 2000). Having been selected for efficiency in egg production, the amount of muscle in laying hens is limited to what is necessary to keep body structural soundness. Our data shows that neither less nor additional protein is stored in the body when the nutritional intake is changed; the excess in available amino acids is likely to be channelled to formation of proteins in the egg. Content deposition fat occurred at a later age than protein deposition regardless of genetic line and nutritional program. The content fat deposition significant difference (P<0.05) in 72th, occurring later for P2 and P3 may be related to a higher availability of metabolites from fat catabolism after peak growth for all other carcase components has occurred. Any selection pressure placed on reduction of body fat will mostly likely be reflected in the form of a correlated response to selection. Raising birds on a non-standard nutritional program (*e.g.*, P3) may produce changes in the amount of body content fat of fat tissue.

Table 1 - Live body weight and chemical composition (protein, fat, ash, and water content) of layers W36 and Brown submitted to different nutritional programs*

Nutrient content (g/1000g) Live body weight (g)	Nutritional Programs	Lines	CV (%)

	P1	P2	P3	W36	Brown	
		Day 1				
Body weight	37.54	37.29	37.28	37.64 ^{a}	37.10^{b}	1.05
Crude Protein	293.29	342.55	324.94	317.14	323.38	12.59
Crude fat	87.40	98.94	87.78	97.06^{a}	85.68^{b}	11.07
Ash	30.10	31.72	30.57	31.56	30.03	8.56
Water	589.21	526.79	556.71	554.23	560.91	8.24
		6^{th} week				
Body weight	417.36^{b}	417.52^{b}	432.40^{a}	392.37^{b}	452.53^{a}	2.43
Crude Protein	250.68	216.45	229.69	248.46^{a}	216.09^{b}	10.22
Crude fat	109.32^{a}	84.65^{b}	98.25^{ab}	115.58^{a}	79.23^{b}	9.55
Ash	33.24	31.80	35.77	33.05	34.16	8.96
Water	606.76^{b}	667.10^{a}	636.29^{ab}	602.91	670.52	4.78
		16^{th} week				
Body weight	1292.55^{b}	1308.80^{ab}	1331.11^{a}	1187.61^{b}	1434.04^{b}	1.99
Crude Protein	159.97	201.50	228.88	223.70^{a}	169.87^{b}	11.01
Crude fat	139.79^{a}	138.38^{ab}	119.25^{b}	136.66	128.29	11.73
Ash	33.43	32.49	31.99	32.89	32.38	8.14
Water	687.35^{a}	627.63^{b}	599.34^{b}	606.75^{b}	669.46^{a}	4.19
		32^{th} week				
Body weight	1522.16^{b}	1568.18^{b}	1630.65^{a}	1366.57^{b}	1780.75^{a}	3.87
Crude Protein	164.51	174.71	190.33	172.24	180.80	12.53
Crude fat	155.77	172.82	160.26	153.52^{b}	172.38^{a}	17.33
Ash	39.39	35.63	39.61	37.37	39.05	11.50
Water	640.32	616.85	609.80	636.87	607.77	9.02
		36^{th} week				
Body weight	1627.40^{b}	1636.37^{b}	1723.57^{a}	1450.12^{b}	1874.78^{a}	2.98
Crude Protein	217.21	190.05	202.09	209.42	192.81	15.81
Crude fat	174.81	185.61	184.56	189.59^{a}	173.73^{b}	13.55
Ash	41.15^{a}	37.25^{ab}	33.12^{b}	36.63^{b}	37.72^{a}	10.84
Water	566.83	587.08	580.24	564.36	591.74	8.21
		52^{th} week				
Body weight	1675.42^{b}	1669.07^{b}	1738.44^{a}	1481.16^{a}	1907.47^{a}	3.20
Crude Protein	185.96	206.19	200.58	203.19	191.96	10,83
Crude fat	150.87	155.99	163.73	159.69	154.03	17.84
Ash	35.31	32.18	33.38	33.53	33.72	8.58
Water	627.87	605.64	602.31	603.59	620.29	6.11
		72^{th} week				
Body weight	1727.93^{b}	1744.87^{b}	1795.11^{a}	1569.06^{b}	1942.88^{a}	2.42
Crude Protein	177.65	206.12	190.93	188.84	194.30	10.15
Crude fat	136.67^{b}	181.25^{a}	170.35^{ab}	161.75^{b}	163.77^{a}	16.06
Ash	43.57	49.04	40.08	42.51	45.95	14.44
Water	592.11	563.59	598.64	606.90	562.66	14.64

* The day 1 and weeks 4^{th}, 6^{th}, 8^{th}, 12^{th}, and every 4 weeks until week 72 th of age and subjected to chemical composition analysis (MS, EE, PB and ash), but this communication are presented just part these weeks. A detailed description of the chemical composition analysisis reported in Santos (2008).

Bone strength is a complex trait influenced by many factors (Rath *et al.*, 2000) including nutrition. The present data supports the fact that an increased feed intake no resulted in larger ash content in the body for layers. The larger body size for Brown layers of this line when compared to W36 na fase inicial de crescimento (day one through the 16^{th}), especially the 12^{th} ($P<0.05$) probably requires a higher level of bone mineralization, thus the higher amounts and proportions found as more nutrients were made available through a more abundant availability of feed. The later phase in deposition of ashes found for the line Brown is consistent with the other components of live weight; larger, less precocious birds need to accumulate more resources before finalizing growth in a way that supports high reproductive capacity. There may be a physiological limit to velocity of bone mass growth that requires heavier birds a longer time to attain the ideal mineralization of key bones. Selection has altered the efficiency of many physiological processes in domesticated chickens and nutrient utilization, despite a conserved process of digestibility even after many generations of artificial selection, may have resulted in a changed strategy for allocation of nutrients in modern commercial chickens (Jackson & Diamond, 1996). Layers from the two genetic lines had distinct growth profiles and the deposition of nutrients also followed different schedules according to age (*Table 2*).

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