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ENZYME COMPLEX AND WHOLE RICE BRAN ON THE PRODUCTIVE PERFORMANCE AND QUALITY OF EGGS FROM LAYING HENS AT THE SECOND PRODUCTION CYCLE

COMPLEXO ENZIMÁTICO E FARELO DE ARROZ INTEGRAL SOBRE O DESEMPENHO PRODUTIVO E QUALIDADE DOS OVOS DE POEDEIRAS EM SEGUNDO CICLO DE PRODUÇÃO

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Abstract:

The objective of this study was to evaluate the performance as well as the quality of eggs from birds fed diets containing whole rice bran (RB), with or without the addition of an enzyme complex (EC) with different levels of metabolizable energy value. A total of 480 Hisex brown layers were used. The treatments consisted of diets based on corn (C), soybean meal (SBM), rice bran (RB), with or without the inclusion of the enzyme complex (EC) to the diets. Treatments 1, 2, 3, and 4 consisted of the presence of corn (C), soybean meal (SBM) and treatments 5, 6, 7, and 8 consisted of C, SBM, and 20% RB, with or without the inclusion the EC. Treatments 1, 3, 5, and 7 did not receive CE; however, in treatments 3 and 7 there was energy recovery of 100 kcal / kg (negative controls). The EC was added without energy recovery (on top) to treatments 2 and 6, and valued at 100 kcal / kg in treatments 4 and 8. Birds fed RB produced heavier eggs and yolk. Birds fed RB and that received the EC on top had higher feed intake. The highest Haugh unit and best feed conversion per dozen were observed in birds that received only the control treatment or the control diet supplemented with EC in a diet reformulated to 100 kcal ME/kg.

Keywords: alternative food; exogenous enzymes; Hisex brown

Resumo

Objetivou-se avaliar o desempenho produtivo e qualidade dos ovos de aves que receberam dietas contendo farelo de arroz integral (FAI), com ou sem adição de complexo enzimático (CE), com e sem valorização energética. Foram utilizadas 480 poedeiras *Hisex brown*, durante 112 dias experimentais, divididas em oito tratamentos com 12 repetições cada. Os tratamentos 1, 2, 3 e 4 consistiram da presença de milho (M) e farelo de soja (FS), e os tratamentos 5, 6, 7 e 8 consistiram de M, FS e 20% de FAI, com ou sem inclusão do CE. Os tratamentos 1, 3, 5 e 7 não receberam CE; no entanto, nos tratamentos 3 e 7 houve valorização energética de 100 kcal EM/kg (controles negativos). O CE quando presente foi acrescido sem valorização energética (*on top*) nos tratamentos 2 e 6, e valorizado em 100 kcal EM/kg nos tratamentos 4 e 8. Aves que receberam FAI produziram ovos e claras mais pesadas, gemas menos pigmentadas e apresentaram maior peso vivo. Aves que consumiram FAI recebendo CE *on top* ou sem valorização apresentaram maior consumo de ração. Maior unidade *Haugh* e melhor conversão alimentar por dúzia foram observados em aves que receberam tratamento controle ou controle com CE valorizado.

Palavras-chave: alimento alternativo; enzimas exógenas; *Hisex brown*.

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Introduction

The strong genetic improvement experienced by modern laying hens has resulted in birds with high rates of egg production. The second production cycle is a management practice that aims at promoting the rest of the reproduction system of the bird, leading to an ovarian involution in order to regenerate the reproductive capacity, improve eggshell quality, and reduce losses. It allows to extend the economic life of commercial laying hens with high production peaks and a performance similar to the first production cycle. The significant advantage of the second production cycle for the producer is the fast economic return. Within four or five weeks, the birds submitted to the process resume production, reaching the laying peak after around ten to twelve weeks. However, to apply this method, some conditions should be considered, such as the needs of the market, the high costs to change the flock, and the birds physical condition. On the other hand, the worsening of egg quality becomes precocious, regarding mainly the drop in eggshell quality due to physiological and production characteristics that impact egg quality, affecting the laying hen productivity.

In animal nutrition, some foods have stood out because of their quality as a nutrient source or due to the level of inclusion in the diets as for corn and soybean meal, which represent the main grains produced in Brazil(1). One of the problems faced by bird producers is the availability of corn in the market because it is also used in human feeding and biofuel production(2).

Whole rice bran is a byproduct of the polishing of peeled rice that is not submitted to oil extraction and represents 8-10% of the total weight of the grain. Whole rice bran has a relatively low cost, and within some limits, it presents all the conditions to be included in rations for ruminants(3), allowing the reduction in feeding costs. However, its use in animals feeding is very limited due to the presence of anti-nutritional factors, such as phytic acid and non-amilated polysaccharide (NAP). The NAPs are not digested and also impair the digestion and absorption of other nutrients because they hydrate and increase the viscosity of the digesta, impairing thus the activity of endogenous enzymes and the absorption of simple molecules, such as glucose and free amino acids(4). The supplementation of exogenous enzymes to the diet improves the production efficiency of birds as it increases the digestion of low-quality products and reduces the loss of nutrients in the feces(5-7).

Therefore, the objective of this experiment was to evaluate the effect of the inclusion of an enzymatic complex (Allzyme SSF®, Alltech do Brasil) to the diets containing whole rice bran on the productive performance and egg quality of laying hens in the second production cycle.

Material and Methods

This study was carried out in the facilities of the experimental aviary of campus Pelotas Visconde da Graça, of Instituto Federal Sul-rio-grandense, during 112 experimental days, divided in four productive cycles of 28 days each. The Ethics Committee for Animal Experimentation of Universidade Federal de Pelotas approved the procedures carried out in this study registered under the Protocol No. 0777.

We used 480 laying hens of the Hisex brown strain, in the second production cycle, at the initial age of 95 weeks and with mean initial weight of 1342.10 g, housed in a dark house-type shed, in laying cages containing five birds each, totaling 96 cages. Each cage represented an experimental unit.

The experimental design was entirely random with eight treatments and twelve replications/treatment. Treatments 1, 2, 3, and 4 presented the presence of corn (C) and soybean meal (SM); treatments 5, 6, 7, and 8 had C, SM, and 20% of whole rice bran (RB), all with or without the inclusion of an enzymatic complex (EC). Treatments 1, 3, 5, and 7 did not receive the EC; however, in treatments 3 and 7 there was an energetic valorization of 100 kcal ME/kg (negative control). The EC was added without energetic valorization (on top) in treatments 2 and 6, and with the valorization of 100 kcal ME/kg in treatments 4 and 8 (positive control). In other words, i.e., we attributed the release of 100 kcal EM/kg by the EC on the total of the energetic level calculated for the referred diets. We established the levels of valorization to meet the energy release, being above and below the value determined by the manufacturer (75 kcal ME/kg). The diets were isoenergetic (the reduction of the levels was carried out in the nutritional matrix of the enzymatic complex when added to the diets; thus, all the diets were calculated to meet the energy required by this strain). They were also isophosphorus and isocalcium, and the EC was added to the nutritional matrix of the diets according to to the manufacturer's recommendation (150 g/t). The composition of the experimental diets is displayed in Table 1.

The birds were fed at will, using open rail-type feeders, placed in front of the cages and isolated by partitions so that the ration would be supplied to each experimental unit separately, according to the treatments. Water was provided in nipple drinkers, at will. Each cage had two drinkers. The light system followed the recommendations for the strain with 16.5 hours of light daily. The excrement of the birds was collected as they liquefied through the drains to a pit outside the facilities.

The variables of productive performance analyzed were live weight (LW, g), feed intake (FI, g) percentage of eggs produced (PEP, %), feed conversion by the dozen (FC/Dz, kg/dz), and feed conversion per mass (FC/M, kg/kg). These variables were analyzed within each 28-day period, but the variables FI and PEP were monitored daily. On the last day of each productive cycle, we collected five eggs from each experimental unit, totaling 60 eggs/treatment/cycle to carry out the analyses of the variables regarding the external and the internal quality of the eggs. The analyzed variables were egg weight (EW, g), specific gravity (SG), eggshell weight (ESW, g), eggshell thickness (EST, mm), color of the yolk (CY), albumen weight (AW, g), yolk weight (YW, g), and Haugh unit (HU). The values of Haugh unit were obtained by the egg weight (g) and albumen height (MM), according to the following formula [8]:

$$HU = 100 \log(H - \frac{\sqrt{G(30W^{0.37} - 100)}}{100} + 1.9)$$

Where: H = height of thick albumen (millimeters); G = gravitational constant, value 32; W = egg weight (g).

The data were submitted to ANOVA, with significance level of simple and multiple contrasts using the statistical software SAS[9].

Table 1. Percentage composition of the experimental diets

Ingredients (%)	T1	T2	T3	T4	T5	T6	T7	T8
Corn	61.81	61.66	61.67	61.67	38.34	38.34	38.00	38.00
Soybean meal	25.10	25.10	25.10	25.10	23.35	23.35	23.40	23.40
Whole rice bran[1]	0.00	0.00	0.00	0.00	20.00	20.00	20.00	20.00
Oyster shell flour	10.27	10.27	10.27	10.27	10.40	10.40	10.40	10.40
Bicalcium phosphate	1.42	1.42	1.42	1.42	1.20	1.20	1.19	1.19
Soybean oil	0.50	0.50	0.50	0.50	5.18	5.18	5.30	5.30
Salt	0.46	0.46	0.46	0.46	0.46	0.46	0.45	0.45
Mineral and vitamin Premix[2]	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Methionine (%)	0.14	0.14	0.13	0.13	0.14	0.14	0.19	0.19
Inert	0.00	0.00	0.15	0.00	0.53	0.38	0.77	0.62
Lysine (%)	0.00	0.00	0.00	0.00	0.10	0.10	0.10	0.10
EC[3]	0.00	0.15	0.00	0.15	0.00	0.15	0.00	0.15
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Calculated nutritional levels								
ME kcal/kg	2700	2700	2700	2700	2700	2700	2700	2700
CP, %	16.48	16.48	16.48	16.48	16.48	16.48	16.48	16.48
Calcium (%)	4.20	4.20	4.20	4.20	4.20	4.20	4.20	4.20
Available P, %	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35
Total sodium, %	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Methionine + Cysteine, (%)	0.55	0.55	0.55	0.55	0.53	0.53	0.55	0.55
Total Lysine, %	0.88	0.88	0.88	0.88	0.87	0.87	0.91	0.91
Fat, %	3.33	3.33	3.33	3.33	9.84	9.84	9.91	9.91

[1] chemical composition of the whole rice bran: dry matter: 89.60%; crude protein: 11.75%; ashes: 9.60%; gross energy: 3,534 kcal/kg

[2] Guarantee Levels per kilogram of product: vitamin A: 2,500,000 UI, Vitamin D3: 500,000 UI, vitamin E: 1,750 mg, vitamin k3: 375 mg, vitamin B1: 400 mg, vitamin B2:1.100mg, vitamin B6: 750 mg, vitamin B12: 3.000mcg, niacin: 6,500mg, folic acid: 175 mg, pantothenic acid : 2,500 mg, methionine: 300 g, choline: 90 g, manganese: 17,500 mg, zinc: 12,500 mg, iron: 15,000 mg, copper: 2,500 mg, iodine: 90mg,, selenium: 76 mg. ME = metabolizable energy; CP = crude protein; available P = available phosphorus.

[3] Composition of the enzyme complex: phitase, protease, xylanase, ß-glucanase, cellulase, amylase and pectinase.

Results and Discussion

The means of the productive performance of the birds are displayed in Table 2. The likely increment aimed with a second production cycle in laying hens refers to the data compared to the results obtained at the end of the first production cycle, but not to the laying peak of the bird. Therefore, it is expected that such data are inferior to those at the first production cycle of the strain. We verified that the live weight of the birds that received RB in the diet (treatments 5, 6, 7, and 8) was significantly higher, but it did not differ from treatment 4, that did not present RB in its composition. The birds may use the excess of nutrients for tissue growth or fat deposition[10]. The fat may be directed to the plantar pad, carcass, liver, ovary, or as fuel for metabolic processes[11]. The birds that received the treatments 5, 6, and 7 showed a greater feed intake.

In contrast analysis, the group that received RB presented the greatest feed intake. In the present study, although the diets were isoenergetic, the ones formulated with RB presented a higher percentage of soybean oil, producing a lower caloric increment when compared to the diets formulated without the alternative ingredient. This fact may explain the greater feed intake since, according to Moura et al.[12], in birds rearing systems, the intake is regulated by the energetic density of the diet and by the nutritional requirements. Birds in treatment 1 (C/SM) worsened regarding the FC/Dz, as well as those that received RB in the diet (treatments 5, 6, 7, and 8), regardless of the absence or presence of EC. For the simple contrast analysis, we observed a significant difference when treatments 1 and 2 and 4 and 8 were compared.

The parameters of egg production (PEP) and feed conversion per egg mass (FD/M) did not suffer a significant effect by the treatments.

Table 2. Means of the productive performance variables of laying hens in second production cycle, receiving diets containing whole rice bran (RB) and enzymatic complex (EC) during four production cycles

Treat	LW (g)	FI (g)	PEP (%)	FC/Dz (kg/dz)	FC/M (kg/kg)
C/SM	1983.10 ± 43.08^{bc}	158.20 ±3.28^{c}	73.27 ± 3.34	3.23 ± 0.15^{a}	3.10 ± 0.17
C/SM + EC on top	1979.42 ± 46.52^{bc}	168.35 ±3.54^{b}	74.77 ± 3.60	2.78 ± 0.15^{bc}	3.30 ± 0.19
C/SM - EC (100kcal/ME)	1946.09 ± 43.07^{c}	160.38 ±3.28^{b}	75.38 ± 3.34	2.93 ± 0.14^{abc}	3.61 ± 0.17
C/SM + EC (100kcal/ME)	2001.24 ± 37.08^{abc}	165.43 ±2.89^{bc}	71.63 ± 2.94	2.59 0.13 ±^{c}	3.41 ± 0.15
C/SM +RB	2088.12 ±43.07^{ab}	175.34 ±3.28^{ab}	74.92 ± 3.34	2.90 ± 0.14^{abc}	3.33 ± 0.17
C/SM + RB + EC on top	2070.12 ±37.98^{ab}	178.83 ±2.89^{a}	74.15 ± 2.94	2.98 ± 0.13^{ab}	3.43 ± 0.15
C/SM +RB - EC (100kcal/ME)	2101.75 ±37.98^{a}	179.10 ±2.89^{a}	72.32 ± 2.94	3.02 ± 0.13^{ab}	3.45 ± 0.15
C/SM +RB + EC (100kcal/ME)	2104.64 ±37.99^{a}	166.05 ±2.89^{bc}	79.79 ± 2.94	3.10 ± 0.13^{ab}	3.37 ± 0.15
P	0.0337	< 0.0001	0.4837	0.0485	0.6300
CV, %	5.59	87.58	12.25	12.62	13.18
Error	113.95	74.98	8.82	0.37	0.45
Simple contrast					
1x2	Ns	0.0399	Ns	0.0367	Ns
1x5	Ns	0.0005	Ns	Ns	Ns
2x6	Ns	0.0255	Ns	Ns	Ns
3x4	Ns	Ns	Ns	Ns	Ns
3x7	0.0089	<0. 0001	Ns	Ns	Ns
4x8	Ns	NS	Ns	0.0057	Ns
5x6	Ns	Ns	Ns	Ns	Ns
7x8	Ns	0.0023	Ns	Ns	Ns
Multiple contrast					
C/SM x RB	0.0003	<.0001	Ns	Ns	Ns

^{abc}Means followed by different letters in the same column differ by Tukey test (P=0.05); LW = live weight; FI = feed intake; PEP = percentage of eggs produced; FC/Dz = feed conversion per dozen of eggs; FC/M = feed conversion per mass of eggs; Ns= non-significant; C= corn; SM= soybean meal; EC= enzymatic complex; RB= whole rice bran.

In the analysis of the external quality variables (Table 3), we verified that the treatments affected the egg weight significantly. The birds that received the diet containing whole rice bran with and without valorization of the enzymatic complex (treatments 7 and 8, respectively) produced heavier eggs when compared to those produced by birds that received corn and soybean meal with or without the enzymatic complex with the same valorization or with the EC added on top.

The contrast between the treatments that contained corn and whole rice bran revealed heavier egg weight for the treatments with the alternative nutrient. Even with lipoprotein diets, it is likely that the higher level of crude protein of the rice bran has affected the weight of the eggs due to the greatest protein availability of this food. According to Rostagno et al.[13], the level of digestible crude protein by birds is higher in RB (10.20%) than in corn (6.86%), which may have affected the results. The comparison of treatments 4 and 8 revealed greater specific gravity for the treatment that presented C+SM with EC valorized at 100kcal, and this difference favored the treatments when contrasted with treatments C+SM x RB. It is possible that the phytic acid released by the RB interacted with the divalent cation Ca[10] affecting its availability, worsening the specific density of the eggshell, since only treatment 8 had whole rice bran, which may have caused a greater release of phytic acid. However, the present experiment was carried out with laying hens in the second production cycle, and the retention rate of calcium varies according to the age. For young birds, this rate is around 60% while for older birds it is around 40%[14].

In the present experiment, although the specific gravity differed among treatments, it kept the acceptability in market's perspective, because it was above 1.080, which according to Harder et al.[15], is the minimum value for commercial eggshell to resist transportation and processing.

Table 3. Means of the external quality variables of laying hens in second production cycle, receiving diets containing whole rice bran (RB) and enzymatic complex (EC) during four production cycles

Treat	EM (g)	SG	EW (g)	EST (mm)	ESW
C/SM	44.00 ± 2.86	1.086 ± 1.03	70.36 ± 1.10^{ab}	39.83 ± 0.49	6.75 ± 0.09
C/SM + EC on top	47.33 ± 2.99	1.086 ± 1.08	69.00 ±1.15 ^{bc}	40.94 ± 0.50	6.50 ± 0.09
C/SM - EC (100kcal/ME)	41.22 ± 3.14	1.086 ± 1.13	67.03 ± 1.20^{c}	41.64 ± 0.54	6.51 ± 0.10
C/SM + EC (100kcal/ME)	43.78 ± 2.86	1.086 ± 1.02	68.40 ± 1.10^{bc}	41.72 ± 0.50	6.59 ± 0.09
C/SM +RB	49.88 ± 2.98	1.084 ± 1.08	71.13 ± 1.15^{ab}	40.19 ± 0.51	6.49 ± 0.09
C/SM + RB + EC on top	47.70 ± 2.99	1.084 ± 1.08	71.14 ± 1.15^{ab}	40.68 ± 0.51	6.60 ± 0.09
C/SM +RB - EC (100kcal/ME)	48.50 ± 2.99	1.085 ± 1.08	72.60 ± 1.15^{a}	41.16 ± 0.51	6.72 ± 0.09
C/SM +RB + EC (100kcal/ME)	46.65 ± 2.86	1.083 ±1.03	72.39 ± 1.10^{a}	40.77 ± 0.50	6.56 ± 0.09
P	0.5039	0.1319	0.0086	0.1256	0.3436
CV, %	8.48	0.33	5.40	4.18	4.70
Error	9.90	3.56	3.70	1.70	0.30
Simple contrast					
1x2	Ns	Ns	Ns	Ns	Ns
1x5	Ns	Ns	Ns	Ns	0.0438
2x6	Ns	Ns	Ns	Ns	Ns
3x4	Ns	Ns	Ns	Ns	Ns
3x7	Ns	Ns	0.0012	Ns	Ns
4x8	Ns	0.0116	0.0016	Ns	Ns
5x6	Ns	Ns	Ns	Ns	Ns
7x8	Ns	Ns	Ns	Ns	Ns
Multiple contrast					
C/SM x WRB	Ns	0.0033	0.002	Ns	Ns

[abc]Means followed by different letters in the same column differ by Tukey test (P=0.05); EM = egg mass; SG = specific gravity; EW = egg weight; EST = eggshell thickness; ESW = eggshell weight; Ns= non-significant; C= corn; SM= soybean meal; EC= enzymatic complex; RB= whole rice bran.

The contrast between the diets with and without RB without the reduction in energetic levels revealed heavier weight for the eggs from birds fed the control treatment, probably due to the greater calcium availability in corn and soybean meal based diets. The treatments did not affect the parameters eggshell thickness and mass significantly.

Table 4 shows the results found for the internal quality parameters. The color of the yolk presented significant difference among treatments, and it was lower for the eggs from birds that received the diet containing RB because rice and its byproducts are poor in carotenoids. According to Kljak and Karoliv[16], the natural pigment of the yolk results from the deposition of such carotenoids. Usually, a more intense coloration of the yolk in eggs from commercial laying hens is desirable to meet the requirements and expectations of the market, and it depends exclusively on the feeding supplied to the birds, since these birds are not able to synthesize this pigment, but they can absorb from 20 to 60% of the pigments from the ration[17]. When an alternative to corn is used, such as sorghum, rice or wheat grit, that are poor in xanthophyll carotenoids, drastically reducing yolk coloration, it is necessary to add a natural or artificial pigment to the ration so that the market will not reject the product[18,19].

Table 4. Means of the internal quality variables of laying hens in second production cycle, receiving diets containing whole rice bran (RB) and enzymatic complex (EC) during four production cycles

Treat	CY	HU	YW (g)	AW (g)
C/SM	6.00 ± 0.15^{a}	90.47 ± 0.98^{a}	17.56 ± 0.34	41.95 ± 0.75^{ab}
C/SM + EC on top	6.19 ± 0.15^{a}	87.20 ± 1.02^{b}	17.77 ± 0.34	41.44 ± 0.79^{ab}
C/SM - EC (100kcal/ME)	6.20 ± 0.16^{a}	86.37 ± 1.07^{b}	16.86 ± 0.37	40.50 ± 0.83^{b}
C/SM + EC (100kcal/ME)	6.25 ± 0.15^{a}	90.63 ± 0.98^{a}	17.50 ± 0.34	40.40 ± 0.75^{b}
C/SM +RB	5.37 ± 0.15^{b}	88.74 ± 1.02^{ab}	17.60 ± 0.35	42.44 ± 0.79^{ab}
C/SM + RB + EC on top	5.19 ± 0.15^{b}	86.83 ± 1.02^{b}	17.93 ± 0.35	42.60 ± 0.79^{ab}
C/SM +RB - EC (100kcal/ME)	5.19 ± 0.15^{b}	88.83 ± 1.02^{b}	18.20 ± 0.35	43.55 ± 0.79^{a}
C/SM +RB + EC (100kcal/ME)	5.08 ± 0.15^{b}	88.23 ± 0.98^{ab}	18.30 ± 0.34	43.52 ± 0.75^{a}
P	<.0001	0.0121	0.1308	0.0250
CV, %	8.75	3.84	6.55	6.20
Error	0.50	3.38	1.16	16.68
Simple contrast				
1x2	Ns	0.0231	Ns	Ns
1x5	0.0029	Ns	Ns	Ns
2x6	< 0.0001	Ns	Ns	Ns
3x4	Ns	0.0042	Ns	Ns
3x7	< 0.0001	Ns	0.0095	0.0089
4x8	< 0.0001	Ns	Ns	0.0045
5x6	Ns	Ns	Ns	Ns
7x8	Ns	Ns	Ns	Ns
Multiple contrast				
C/SM x RB	< 0.0001	Ns	0.0185	0.0006

[abc] Means followed by different letters in the same column differed by Tukey test (P=0.05); CY = color of the yolk; HU = Haugh unity; YW = yolk weight; AW = albumen weight; NS= non-significant; C= corn; EC = enzymatic complex; RB = whole rice bran.

Haugh unit is obtained by the logarithmic function of albumen height of the egg in relation to its weight. It is universally used due to its easy application and the high correlation with the appearance of the egg when it is broken, being defined as the measurement of the internal quality of the egg[20].

The measurement of albumen height allows determining its quality because as it grows old, the proportion of liquid albumin increases to the detriment of dense albumin[21]. In the present experiment, the treatments 1 and 4 produced greater indices of Haugh unit, and they were numerically superior in eggs from birds that received C+SM with EC valorized in 100kcal. In general, good quality eggs present indices above 72[22]. Such values could be observed in this experiment. When treatments 1, 2, 3, and 4 were compared, the greatest Haugh unity indices were found for treatments 1 and 4.

The comparison of treatments 3 and 7 showed heavier yolk weight for eggs produced by birds that received RB without the energetic valorization of the EC (T7). The lipid composition of the diet affects the composition of fatty acids of the yolk. In the present experiment, the diets that did not contain RB presented a lower percentage of fat (3.33%) compared to those that had RB (9.84% to 9.91%). When the diet presents a greater level of fat, yolk weight increases[23]. Moreover, eggs from birds that received RB with or without EC valorization presented a heavier albumen. Egg weight involves three components: yolk, albumen, and eggshell[24], and the albumen is the component found in the highest percentage (around 60% of the total weight of the egg)[25]. According to the data, heavier eggs corresponded to the heaviest albumen weights; therefore, the better composition of the WRB[14] may have contributed to the increase in albumen weight and hence in egg weight.

Conclusions

In this study, we verified that laying hens in the second production cycle receiving diets containing RB produced less pigmented yolks due to the low level of carotenoids. The inclusion of the enzymatic complex did not present a significant effect, and it did not affect the results in the conditions of this experiment, mostly when associated with diets containing RB.

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