Revista Agrarian
ISSN: 1984-2538

Sodium and potassium at different levels of crude protein for laying quails

Uso de sódio e potássio em diferentes níveis de proteína bruta para codornas em postura

Bruno Andreatta Scottá[1], Talita Pinheiro Bonaparte[2], José Geraldo de Vargas Junior[2], Felipe Barreto Petrucci[3], Danilo Vargas Gonçalves Vieira[4], Julio Francisco Valiati Marin[2], Silvana Marques Pastore[5], Rita da Trindade Ribeiro Nobre Soares[6]

[1] Instituto Federal Goiano, Campus Rio Verde - Rodovia Sul Goiana, Km 1, s/n - Zona Rural, Rio Verde - GO
[2] Universidade Federal do Espírito Santo, Av. Fernando Ferrari, 514 - Goiabeiras, Vitória - ES, 29075-910
3 Copeavi, Av. Francisco Schwartz, 88 - Centro. Santa Maria de Jetibá - ES. CEP: 29.645-000. email: talitabonaparte@gmail.com
[4] Universidade Federal do Tocantins, Av. Paraguai, s/n - Setor Cimba - Lot. Araguaina Sul, Araguaína - TO,
[5]Universidade Federal de Viçosa, Avenida Peter Henry Rolfs, s/n - Campus Universitário, Viçosa - MG,
[6] Universidade Estadual do Norte Fluminense, Av. Alberto Lamego, 2000 - Parque California, Campos dos Goitacazes - RJ,

Recebido em: 25/09/2015 Aceito em:04/04/2017

Abstract. The objective of this experiment was to evaluate the performance of laying quails fed diets containing 21 and 24% crude protein, three electrolytic balances (200, 275 and 350 mEq/kg diet) and two forms of electrolytic balance increase (potassium and sodium + potassium). A total of 720 quail with 120 days of age, for 84 days, divided into four periods of 21 days, in two tests distributed in random blocks design with six replicates and 10 birds per experimental unit. Were evaluated three levels of electrolyte balance and the inclusion of two sources of cations in the feed. The comparison of means was performed by Student Newman-Keuls test (SNK) and the F-test (5%). For the level of 21% crude protein, the addition of potassium carbonate (K_2CO_3) promoted increase in egg mass. For the level of 24%, the results showed that the combined addition of potassium carbonate and sodium carbonate (K_2CO_3 + Na_2CO_3) presented better laying rate, egg mass, feed intake and feed conversion. Regardless of the protein level utilized, the best results were achieved with 200 mEq/kg diet.

Keywords: electrolytic balance, potassium carbonate, sodium carbonate

Resumo. O experimento foi realizado com o objetivo de avaliar o desempenho de codornas poedeiras alimentadas com rações contendo 21 e 24% de proteína bruta, três balanços eletrolíticos (200, 275 e 350 mEq/ kg de ração) e duas formas de aumento de balanço eletrolítico (potássio e sódio + potássio). Foram utilizadas 720 codornas com 120 dias de idade, durante 84 dias, subdivididos em quatro períodos de 21 dias, em dois ensaios distribuídos em delineamento em blocos ao acaso com seis repetições e dez aves por unidade experimental. Foram avaliados três níveis de balanço eletrolítico e a inclusão de duas fontes de cátions na ração. A comparação das médias foi realizada pelo teste de Student Newman-Keuls (SNK) e pelo teste F (5%). Para o nível de 21% de proteína bruta, a adição de carbonato de potássio (K_2CO_3) proporcionou aumento na massa de ovos. Para o nível de 24%, os resultados mostraram que a adição conjunta de carbonato de potássio e carbonato de sódio (K_2CO_3 + Na_2CO_3) apresentaram melhor taxa de postura, massa de ovos, consumo de ração e conversão alimentar. Independentemente do nível de proteína utilizado, os melhores resultados foram obtidos com 200 mEq/ kg de ração.

Palavras-chave: balanço eletrolítico, carbonato de potássio, carbonato de sódio

Introduction

The creation of quail for egg production is one of the activities that has been outstanding for the rate, the high rate of bird posture and the small space used for the production (Guimarães et al., 2014). With the expansion of activity, and advances in genetics, surveys were conducted in order to establish and constantly update the appropriate levels of dietary nutrients, which can contribute to greater productive performance (Costa et al., 2011).

Advances in animal feed allow the formulation of diets with minimal cost and maximum economic return (Silva et al., 2012). The nutritional aspect, minerals and their interrelationships are of great importance. According to Araújo et al., (2011), the Na^+, K^+ and Cl participate in the formulation of rations for birds not only to meet the requirements of each mineral, but also to promote an optimal balance of electrolytes and thus meet growth requirements.

Changes in dietary electrolyte balance are performed in order to improve the performance of the birds, where the reduction in crude protein level in the diet is adopted (Oliveira et al., 2012). Several fatorem can interfere with the electrolyte balance (BE), among them, the room temperature and diet composition (Oliveira et al., 2010).

The use of electrolytes can be implemented as an alternative to minimize the heat stress of the poultry via drinking water or in feed. The main salts are used include potassium chloride (KCl) and ammonium chloride (NH_4Cl_2), which are incorporated in the summer feed (Matos et al., 2011).

The electrolytes sodium, chloride and potassium participate in physiological processes such as the maintenance of osmotic pressure, synthesis of tissue proteins, the intracellular and extracellular maintaining homeostasis, maintaining the electrical potential of the cell membrane homeostasis acid base, and the operation the enzyme and the nerves (Oliveira et al., 2012).

Another important factor is the reduction of crude protein of feed the birds because by reducing the use of soybeans in diets and increased supplementation of industrial amino acids, the electrolyte balance of the feed can be changed (Albino et al., 2014), making it necessary to adjust the same in the diet to maintain internal acid-base balance of the animal (Minafra et al., 2009).

The reduction of the crude protein (CP) and supplemented with synthetic amino acids allows the aminoacid balance according to the actual requirements of poultry, with reduced nitrogen excretion associated with the lower heat generated by the ingested amino acid catabolism (Matos et al. , 2011).

Given the above, this research aimed to evaluate the electrolyte balance in diets with protein reduction on performance of Japanese quails in production.

Material and Methods

The experiment was conducted in the aviculture sector of the Center of Agrarian Sciences of Universidade Federal do Espírito Santo, where 720 female Japanese quails (*Coturnix coturnix japonica*), at initial age of 120 days were utilized for a period of 84 days, distributed in 21-day periods.

The design was of randomized blocks, in order to avoid effect of the positioning of cages on the floors and in the shed on the treatments, with three electrolytic balances (200, 275 and 350 mEq/kg of diet) and two forms of electrolytic balance increase (potassium and sodium + potassium), for two different levels of crude protein (210 and 240 g/kg CP). Considering that two trials with six treatments each, six repetitions and 10 birds per experimental unit.

The statistical analyses were performed using the program SAEG - System for statistical analysis and Genetics (UFV, 1999). The comparison of the averages of the electrolytic balance levels was accomplished through the Student Newman-Keuls test (SNK), while that of the different sources of inclusion of cations was analyzed through the F-test for the comparison of averages, both 5% of significance. Regardless of the effects of interaction with the crude protein levels, decomposition was carried out so as to study the effects of electrolytic balances and of the form of increase of supplementation within each crude protein level.

Experimental diets (Table 1) were formulated based on corn and soybean meal, so as to contain the same level of metabolizable energy (2,900 kcal ME/kg of diet), digestible lysine (0,950%), methionine + digestible cystine (0,729%) and calcium (2,5%).

Revista Agrarian
ISSN: 1984-2538

Table 1. Basal diet utilized in the experiment of electrolytic balance

Ingredients	210 g/kg CP	240 g/kg CP
Corn	563,47	526,06
Soybean meal 45%	227,95	194,15
Corn gluten 60%	54,34	150,33
Meat and bone meal 45%	51,39	33,06
Limestone	50,41	52,18
Dicalcium phosphate	---	4,63
Common salt	2,45	2,79
L-Lysine HCl	1,36	1,87
DL-Methionine	2,03	0,45
L-Threonine	1,09	0,03
Soybean oil	11,06	---
Mineral-vitamin mix	4,00	4,00
CL-Choline	0,45	0,45
Inert (washed sand)	30,00	30,00
Total	1000,00	1000,00
Chemical composition		
ME, kcal/ kg diet	2.900	2.900
Crude protein	210,00	240,00
Calcium	25,00	25,00
Digestible phosphorus	3,50	3,50
Sodium	1,50	1,50
Potassium	6,19	5,47
Chloride	2,58	2,77
Digestible lysine	9,50	9,50
Digestible M + C	8,70	8,70
Digestible threonine	7,80	7,80
Total glycine + serine	20,96	22,33
Digestible arginine	11,75	11,86
Digestible tryptophan	1,87	1,89
Electrolytic balance, mEq/ kg	153	128

CP - crude protein; ME - metabolizable energy. Multi-mix complex (g/kg): choline - 43,33; methionine - 181,15; Growth promoter - 1,167; antioxidant 2,5.

These recommendations are in accordance with the NRC (1994), except for crude protein and electrolytic balances. For the obtainment of the different electrolytic balances, potassium carbonates (K_2CO_3) and potassium carbonate + sodium carbonate (K_2CO_3 + $NaCO_3$) were added, replacing the inert material (Table 2).

The lighting program utilized was of 17 (seventeen) hours of light, by means of timer-type light controller, and measurements of temperature and humidity inside the shed were recorded once daily, through maximum and minimum and dry and wet bulb thermometers.

Laying rate (%), average egg weight (g), egg mass (g of egg/quail/day), feed intake (g/bird/day), feed conversion (g of diet/g of egg), final weight (g) and weight gain (g) were analyzed.

For the determination of average egg weight, egg mass and feed conversion (g of diet/g of egg), the eggs of the last four days of each experimental period were collected, identified and weighed.

Table 2. Levels of supplementation with potassium and sodium sources in the composition of experimental diets

Treatment	Basal diet	Inert	K_2CO_3	Na_2CO_3
		210 g CP/ Kg		
200 mEq	970,00	26,752	3,248	---
	970,00	24,059	2,575	3,366
275 mEq	970,00	21,569	8,431	---
	970,00	14,582	6,684	8,734
350 mEq	970,00	16,390	13,610	---
	970,00	5,100	10,790	14,110
		240 g CP/ Kg		
200 mEq	970,00	25,024	4,976	---
	970,00	20,899	3,945	5,156
275 mEq	970,00	19,842	10,158	---
	970,00	11,419	8,054	10,527
350 mEq	970,00	14,660	15,340	---
	970,00	1,943	12,160	15,897

CP - crude protein; K_2CO_3 - potassium source utilized, with 56,58% potassium; Na_2CO_3 - sodium source utilized, with 43,29% sodium. Atomic weight utilized for the calculation of electrolytic balance: Na - 22,9; K - 39,1 and Cl - 35,45. The addition of potassium and sodium to achieve the desired electrolytic balance was done considering 50% for each cation (K^+ and Na^+).

For the control of feed intake, diets concerning each experimental unit were conditioned in plastic containers duly identified; average feed intake was measured at the end of each 21-day period, by the difference between the feed supplied and leftovers. Dead birds and leftovers were weighed for adjustment of the control of intake, animal weight gain, egg laying and feed conversion at the end of each period.

Results and Discussion

The average maximum temperature observed was 27,6 ± 3,6° C and the minimum of 19,4 ± 4,9° C and relative humidity of 81,0 ± 9,0. In adulthood, the thermal comfort of the quail is between 18 and 22° C and relative humidity of 65 to 70 (Oliveira, 2007). In this way, the values found can be observed that the quails were subjected to heat stress during the experiment.

To assess the effects of electrolyte balance, and the balance sheet increase fashion to the level of 210 gkg crude protein (table 3), was observed for feed intake, egg average weight and feed conversion, no significant effect. On the other hand, laying rate and egg mass, showed significant effect at the 5 level of probability, with birds fed with rations containing 200 mEq/kg, showed the best performance for these characteristics.

When this data is compared with the literature, it is below the value suggested by Leeson & Summers (2001) which was of 250 mEq/kg. Vieites et al. (2005) working with broilers of 1 to 42 days of age recommended value electrolytic balance in the range of 160 to 190 mEq/kg. According to Rostagno et al. (2011) in normal rations for laying birds, the recommendation for chickens is light and semipesadas chickens, 189,83 in posture, is 191,74 mEq/kg.

Rodrigues et al. (2015) found significant difference for productive parameters (feed and

Revista Agrarian
ISSN: 1984-2538

water consumption, egg production, and average weight mass of eggs) of Japanese quail in the initial production cycle, when considering different levels of electrolyte balance (between 117 and 166 mEq/kg) and crude protein in the diet (17 and 20), however it was not observed significant effect on feed conversion for mass and per dozen eggs.

Table 3. Effect of different electrolytic balance (EB) and different ion sources in diets on the performance of Japanese quails fed diets containing 21% crude protein

	Productive characteristic				
EB (mEq/ kg)	FI (g/bird/day)	LR (%)	AEW (g)	EM (g/bird/day)	FC (g/g)
200	25,56	89,20a	11,83	10,55a	2,427
275	25,48	85,63b	11,86	10,16b	2,510
350	25,08	83,93b	11,59	9,73c	2,581
Ion source					
K_2CO_3	25,00	87,30	11,79	10,29x	2,436
$K_2CO_3 + Na_2CO_3$	25,74	85,20	11,73	10,00y	2,577
Effect					
EB	NS	*	NS	*	NS
Ion source	NS	NS	NS	*	NS
EB × ion source	NS	NS	NS	NS	NS
C.V. (%)	6,449	2,648	2,303	2,738	7,409

FI - feed intake; LR - laying rate; AEW - average egg weight; EM - egg mass; FC - feed conversion; K_2CO_3 - potassium carbonate; Na_2CO_3 - sodium carbonate; CV - coefficient of variation; * - significant effect at 5% probability by the SNK test; NS - non-significant effect.

The feed conversion per egg mass was not affected by different levels of electrolyte balance, getting average considered normal for laying quail and similar to the values cited by (Costa et al., 2011 and Rodrigues et al., 2015).

To reduce protein in the diet, Matos et al. (2011) observed lower overall weight and reduction in weight gain and average daily weight gained in the initial phase, however, when was made the correction of electrolyte balance of the diet for 250 mEq/kg with lower content of crude protein, there was improvement in weight. However, the total period, this improvement was not observed when reduced protein and supplementation with the salts. The worsening of weight gain reflected in feed conversion, which worsened in two phases studied.

On the results observed, Matos et al. (2011) suggested caution about the decision by formulations with lower crude protein content, even with the correction of electrolyte balance, since it was observed significant drop of some performance characteristics, as verified in this research, to the rate of production and egg mass.

Giacobbo et al. (2014) evaluated levels of crude protein (18; 17,28; 16,56 and 15,84) and electrolyte balance (200 and 240 mEq/kg^{-1}) in the feed of chickens and found that the protein reduction caused increasing linear effect (P<0,01) on the feed conversion, and descending to the linear effect weight gain (P<0,01) of birds who consumed with BE of 240 mEq/kg^{-1}, and quadratic effect (P<0,05) for those who consumed with BE of 200 $mEq./kg^{-1}$, being the level of 17,54 what provided the greatest weight gain. The use of sodium bicarbonate and potassium chloride was not efficient in improving the performance characteristics of the birds, since no performance improvements were observed when changing the BE of 200 to 240 mEq/kg^{-1} in the diets.

Vieites et al. (2011) observed quadratic effect on weight gain of birds getting rations to BE varying from 200 to 400 mEq/kg being the level the 300 mEq/kg which provided the best weight gain. However, it should be emphasized that these researchers worked with BE levels higher than those used in this study (200 and 240 mEq/kg), which caused the difference in performance.

Revista Agrarian
ISSN: 1984-2538

Analyzing the ions source used, found that for the characteristic egg mass, should be added to the electrolyte balance, increase the K_2CO_3. In rations containing 240 g/kg crude protein (table 4) is observed effect not significant different electrolytic balance sheets on feed intake, laying rate, feed conversion and egg mass. However, it is observed effect of different electrolyte balance sheets on the average weight of eggs, with larger eggs weight, for birds fed 200 mEq/kg.

Table 4. Effect of the different electrolytic balances (EB) and ion sources on the performance of Japanese quails fed diet containing 24% crude protein

	Productive characteristic				
EB (mEq/ kg)	FC (g/bird/day)	LR (%)	AEW (g)	EM (g/bird/day)	FC (g/ g)
200	25,45	83,48	11,82a	9,86	2,586
275	24,90	82,22	11,67ab	9,59	2,600
350	24,46	83,74	11,48b	9,62	2,549
Ion source					
K_2CO_3	25,48x	81,31y	11,63	9,46y	2,696y
$K_2CO_3 + Na_2CO_3$	24,40y	84,99x	11,68	9,92x	2,460x
Effect					
EB	NS	NS	*	NS	NS
Ion source	*	*	NS	*	*
EB × ion source	NS	NS	NS	NS	NS
CV (%)	4,594	3,138	2,238	3,744	5,441

FI - feed intake; LR - laying rate; AEW - average egg weight; EM - egg mass; FC - feed conversion; K_2CO_3 - potassium carbonate; Na_2CO_3 - sodium carbonate; CV - coefficient of variation; * - significant effect at 5% probability by the SNK test; NS - non-significant effect.

To evaluate the ion source, improving posture, rate of egg mass and feed conversion, when added simultaneously K_2CO_3 and Na_2CO_3. The largest feed consumption was observed with the addition only of K_2CO_3, for changing the electrolyte balance. The difference in the use of ion source for transfusions increase in two levels of crude protein, could be due to heat stress observed during the experimental period.

The birds in an attempt to maintain the normal body temperature, increase respiratory rate, which is the main way that these animals use to dissipate heat. This increase leads to greater loss of CO_2 by decreasing the content of this in the blood, thus decreasing the partial pressure of CO_2 (pCO_2-), which leads to a drop in concentration of carbonic acid, causing a reduction in the excretion of hydrogen in an attempt to try to keep the acid-base balance (Teeter et al., 1985), this process known as respiratory alkalosis

The heat stress accompanied by respiratory alkalosis in birds can also affect electrolyte balance, and second Belay et al. (1992), the heat stress has adverse effect on the mineral balance, increasing the excretion of various minerals. Deyhim et al. (1990) observed negative balance of sodium and potassium in birds stressed by high temperatures, due to the increase in urinary excretion.

According to Bacila (1980), the respiratory alkalosis in mammals, causes decreased competition between hydrogen and potassium by exception and therefore increases urinary loss of potassium in the urine. Excess potassium ions compete with anions renal tubular fluid caps, preventing the removal of hydrogen which is absorbed. This mechanism if present in birds, could explain the increase in need of potassium during the period of heat stress.

Another point to be considered in the observation of the data of this research, is the increased heat of the protein metabolism. Thus, the birds fed with rations containing 240 g/kg PB, this level which is above the need of quail in this phase of life, which is 210 g/kg PB (NRC, 1994), may have suffered more from the heat stress than animals fed 210 g/kg PB.

Therefore, to the level of 210 g/kg PB where the birds were stressed by heat, but without excess PB the best results were obtained with the single addition of K_2CO_3, i.e. the quails were with potassium deficiency for this degree of stress, but not sodium, which indicates that the quails may present greater control over excretion of sodium than potassium for this level of crude protein and degree of caloric stress. On the other hand, birds in heat stress and fed with excess PB (240 g/kg), the greater control of excretion of sodium on the potassium is not observed, because the addition of both was necessary for better performance, this was probably due to the greater caloric stress.

Conclusions

Birds fed normal levels of crude protein (210 g/kg CP) and birds fed increased levels of crude protein (240 g/kg CP) presented better performance when receiving diets containing 200 mEq/kg electrolytic balance. The increase in the electrolytic balance with addition of potassium source to animals fed normal levels of crude protein under heat stress is sufficient to maintain animal productivity, whereas in increased levels of protein, the combined application of a potassium and sodium source becomes necessary.

References

ALBINO, L. F. T.; CARVALHO, B. R.; MAIA, R. C.; BARROS, V. R. S. M. **Galinhas Poedeiras: Criação e Alimentação.** Viçosa, Minas Gerais: Aprenda Fácil, 2014. 376p.

ARAÚJO, G.M.; VIEITES, F.M.; BARBOSA, A.A. et al. Variação aniônica da dieta sobre características ósseas de frangos de corte: resistência à quebra, composição orgânica e mineral. **Arquivo Brasileiro de Medicina Veterinária e Zootecnia**., v.63, p.954-961, 2011.

BACILA, M. **Bioquímica veterinária**. São Paulo: J. M. Varela, 1980. 534p.

BELAY, T.; WIERNUSZ, C.J.; TEETER, R.G. Mineral balance and urinary and fecal mineral excretion profile of broilers housed in thermoneutral and heat-distressed environments. **Poultry Science**, v.71, p.1043-1047, 1992.

COSTA, F G. P.; RODRIGUES, L. R.; GOULART, C. C.; OLIVEIRA, C. F. S.; RODRIGUES, V. P.; SILVA, J. H. V. Nutritional potassium requirement for laying Japanese quails. **Revista Brasileira de Zootecnia**, v.40, p.2754-2759, 2011.

DEYHIM, F.; BELAY, T.; TEETER, R.G. The effect of heat distress on blood gas, plasma and urine concentration of Na, K, Cl of broiler chicks. **Poultry Science**, v.69, p.42, 1990.

GIACOBBO, F.C.N.; KLOSOWSKI, E.S.; NUNES, R.V.; SANGALI, C.P.; BRUNO, L.D.G.; YOSHIHARA, C.R.F.; OLIVEIRA, A.C.; FREITAS, D.C. Efeito de diferentes níveis de proteína bruta e balanço eletrolítico sobre o desempenho, parâmetros sanguíneos e características ósseas de frangos de corte na fase de 36 a 42 dias de idade. **Semina: Ciências Agrárias**, Londrina, v.35, n. 4, p.2175-2184, 2014.

GIACOBBO, F.C.N.; KLOSOWSKI, E.S.; NUNES, R.V.; SANGALI, C.P.; BRUNO, L.D.G.; YOSHIHARA, C.R.F.; OLIVEIRA, A.C.; FREITAS, D.C. Efeito de diferentes níveis de proteína bruta e balanço eletrolítico sobre o desempenho, parâmetros sanguíneos e características ósseas de frangos de corte na fase de 36 a 42 dias de idade. **Semina: Ciências Agrárias**, Londrina, v.35, n.4, p.2175-2184, 2014.

GIACOBBO, F.C.N.; SANGALI, C.P;. KLOSOWSKI, E.S. BRUNO, L.D.G.; NUNES, R.V.; TSUTSUMI, C.Y. Níveis de proteína bruta e balanço eletrolítico para frangos de corte em fase inicial. **Agrária - Revista Brasileira de Ciências Agrárias**, v.9, n.4, p.626-632, 2014.

GUIMARÃES, M. C. C.; FURTADO, D. A.; NASCIMENTO, J. W. B.; TOTA, L. C. A.; SILVA, C. M.; LOPES, K. B. P. Efeito da estação do ano sobre o desempenho produtivo de codornas no semiárido paraibano. **Revista Brasileira de Engenharia Agrícola e Ambiental**, v.18, p.231-237, 2014.

LESSON, S.; SUMMERS, J.D. **Nutrition of chicken**. 4.ed. Guelph: University Books, 2001. 415p.

MATOS, M.B.; FERREIRA, R.A.; COUTO, H.P.; SAVARIS, V.D.L. SOARES, R.T.R.N. OLIVEIRA, N.T.E. Balanço eletrolítico da dieta e desempenho de frangos em condições naturais de estresse calórico. **Arquivo Brasileiro de Medicina Veterinária e Zootecnia**, v.63, n.6, p.1461-1469, 2011.

MINAFRA, C. S.; MORAES, G. H. K.; LOPES, A. C. C.; JÚNIOR, C. O. L.; VIEITES, F. M.; REZENDE, C. S. M.; VIU, M. A. O. Balanço eletrolítico e proteico dietéticos sobre as aminotransferases hepáticas, renais e séricas e teores séricos de magnésio e cloro de frangos de corte. **Ciência Animal Brasileira**, v.10, n. 2, p. 425-437, 2009.

NATIONAL RESEARCH COUNCIL - NRC, Nutrient requirements of poutry. National Academic Press, Washington, D.C., 1994, p.44-45.

OLIVEIRA, M.C.; ARANTES, U.M.; STRINGHINI, J.H. Efeito do balanço eletrolítico da ração sobre parâmetros ósseos e da cama de frango. **Revista Biotemas**, v.23, n.1, p.203-209, 2010.

OLIVEIRA, C. F.S.; COSTA, F. G. P.; SILVA, J. H. V.; GOULART, C. C.; SARAIVA, E. P.; GIVISIEZ, P. E. N.; LOBATO, G. B. V.; BEZERRA, R.M. Electrolyte balance in diets with reduced protein for semi-weighted laying hens in the second production cycle. Revista Brasileira de Zootecnia, v.41, n.7, p.1671-1675, 2012.

OLIVEIRA, B. L. Manejo em granjas automatizadas de codornas de postura comercial. In: III Simpósio Internacional de Coturnicultura, 2007, Lavras, **Anais...** Minas Gerais: Núcleo de Estudos em Ciência e Tecnologia Avícolas, 2007. p.11-16.

RODRIGUES, L.R.; FURTADO, D.A.; COSTA, F.G.P.; NASCIMENTO, J.W.B. Balanço Eletrolítico em dietas com proteína reduzida para codornas japonesas no primeiro ciclo de produção. **Revista Verde de Agroecologia e Desenvolvimento Sustentável**, v.10, n.3, p.01-07, 2015.

ROSTAGNO, H.S. **Tabelas brasileiras para aves e suínos - Composição de alimentos e exigências nutricionais**. 2.ed. Viçosa, MG: Universidade Federal de Viçosa, 2000. 141p.

SAEG, UNIVERSIDADE FEDERAL DE VIÇOSA - UFV. **Sistema de análises estatísticas e genéticas - SAEG**. Versão 9.1. Viçosa, MG, 2007. 59p.

SILVA, J.H.V.; JORDÃO FILHO, J.; COSTA, F.G.P.; LACERDA, P.B.; VARGAS, D.G.V.; LIMA, M.R. Exigências nutricionais de codornas. **Revista Brasileira de Saúde e Produção Animal**, v.13, n.3, p.775-790, 2012.

TETTER, R.G. Chronic heat stress and respiratory alkalosis: occurrence and treatment in broiler chicks. **Poultry Science**, v.64, p.1060-1064, 1985.

VIEITES, F. M.; FRAGA, A. L.; SOUZA, C. S.; ARAÚJO, G. M.; VARGAS JÚNIOR, J. G. V.; NUNES, R. V.; CORRÊA, G. S. S. Desempenho de frangos de corte alimentados com altos valores de balanço eletrolítico em região de clima quente. **Arquivo Brasileiro de Medicina Veterinária e Zootecnia**, v.63, n.2, p.441-447, 2011.

VIETES F.M.; MORAES G.H.K.; ALBINO L.F.T. et al. Balanço eletrolítico e níveis de proteína bruta sobre o desempenho, o rendimento de carcaça e a umidade da cama de frangos de corte de 1 a 42 dias de idade. **Revista Brasileira Zootecnia,** v.34, n.6, p.1990-1999, 2005.