Revista Brasileira de Ciência Avícola
ISSN: 1516-635X
revista@facta.org.br
Fundação APINCO de Ciência e Tecnologia Avícolas
Brasil

Petrolli, TG; Junqueira, OM; Domingues, CHF; Pereira, ASC; Santos, ET; Rocha, RX
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Revista Brasileira de Ciência Avícola, vol. 18, núm. 1, enero-marzo, 2016, pp. 29-34
Fundação APINCO de Ciência e Tecnologia Avícolas
Campinas, Brasil

Brazilian Journal of Poultry Science
Revista Brasileira de Ciência Avícola
ISSN 1516-635X Jan - Mar 2016 / v.18 / n.1 / 029-034
http://dx.doi.org/10.1590/1516-635x1801029-034

Effects of the Addition of Glucose, Sodium Bicarbonate, and Vitamin E to the Drinking Water of Pre-Slaughter Broiler Chickens on Carcass Yield, Gastric Emptying and Meat Quality

■Author(s)

Petrolli TG[I]
Junqueira OM[I]
Domingues CHF[I]
Pereira ASC[II]
Santos ET[II]
Rocha RX[III]

[I] Universidade Estadual Paulista "Júlio de Mesquita Filho", Jaboticabal, SP
[II] Faculdade de Medicina Veterinária e Zootecnia, FMVZ/USP, São Paulo, SP
[III] Universidade do Oeste de Santa Catarina, Xanxerê, SC

■Mail Address

Corresponding author e-mail address
Tiago Goulart Petrolli.
Rua Dirceu Giordani, s/n – Jardim Universitário, 89820-000. Xanxerê, SC, Brazil.
Phone: (49) 34417099
Email: tiago.petrolli@unoesc.edu.br

■Keywords

Broiler slaughter, poultry farming, pre-slaughter feed withdrawal, tocopherol.

Submitted: March/2015
Approved: August/2015

ABSTRACT

An experiment was conducted of the poultry facilities of La Salle Agricultural College in Xanxerê, SC, Brazil, to evaluate the effect of the administration of sodium bicarbonate, glucose and vitamin E to the drinking water during pre-slaughter feed withdrawal on carcass yield, organ relative weights (heart, liver, proventriculus, and gizzard), gizzard emptying, and meat quality of broiler chickens. The applied treatments were: water as control; 50g/L of glucose; 50g/L de glucose + 200mg/L of vitamin E; 75g/L of glucose; 75g/L + 200mg/L of vitamin E; 0.45% of sodium bicarbonate; 0.45% of sodium bicarbonate + 200mg/L of vitamin E; 0.55% of sodium bicarbonate; 0.55% of sodium bicarbonate + 200mg/L of vitamin E; 200mg/L de vitamin E. On the last day before slaughter, during the water diet period,500 birds were distributed in a completely randomized experimental design with ten treatments and ten replicates of five birds each. No difference in broiler carcass yield and organ relative weights was found. There were no significant changes in gizzard contents, in ultimate meat, cooking loss, shear force value, or in the meat color parameters L* (lightness), a* (redness) and b* (yellowness). It was concluded is that the addition of glucose, sodium bicarbonate, and vitamin E to the drinking water during pre-slaughter feed withdrawal period has no influence on carcass yield or on relative organ weight, neither on the emptying of the gizzard contents and the meat quality of broiler chickens.

INTRODUCTION

Pre-slaughter feed withdrawal is a common practice used in the poultry industry to reduce contamination in the processing plant and to improve production efficiency because the feed provided to the broilers a few hours before slaughtering is not converted into meat (Mendes, 2001b). Additionally, the purpose of withdrawing feed before shipping the broilers to the processing plant reduces the occurrence of carcass contamination (Rui *et al.*, 2011).

The duration of the feed withdrawal period has been widely discussed, varying from 8 to 12 hours, but it can be longer depending on the logistics of the company, distance to the processing plant, and holding time at lair age (Northcutt *et al.*, 1997; Rui *et al.*, 2011). In some cases, feed withdrawal can exceed the recommended 12-hour period, which can affect various metabolic processes. Food deprivation causes metabolic inversion from anabolism to catabolism, including lipogenesis inversion to lipolysis and reduction of the metabolic rates. Blood glucose of broiler chickens during feed withdrawal decreases rapidly, causing high consumption of the glycogen present in the liver. Warriss *et al.* (1988) stated that the liver glycogen is almost completely metabolized up to six hours of feed withdrawal. In addition,

such withdrawal leads to different physiological and behavioral responses, indicating that the broilers are likely under stress during this period (Whiting *et al.*, 1991; Castro *et al.*, 2008).

It is worth noting that many environmental factors may affect the birds' muscle metabolism. These changes are responsible for the differences in the final meat characteristics, and the nature of such changes is affected by the severity of stress and the degree of bird's resistance to stress (Duke *et al.*, 1997).

The quality of chicken meat is a result of complex interactions between the bird's genotype and environmental influences. For instance, in broilers animals subjected to heat stress, which causes fast muscle glycolysis, there is a decrease in meat pH value and alterations in muscle *rigor mortis* (Rasmussen & Mast, 1989). As a result of metabolic changes, muscle temperature often rises and glycogen is depleted, resulting in the accumulation of lactic acid in the muscle (Lyon *et al.*, 1991). Such combined conditions cause an exaggerated transformation of the muscle into meat (Ali *et al.*, 2008), resulting in excessive protein denaturation. The meat from birds that suffered pre-slaughter stress may become pale, soft, and exudative (PSE) 24 hours *post mortem*. Such condition often results in increased cooking loss, reduced juiciness, and lower meat yield during processing (Ali *et al.*, 1999). Ali *et al.* (2008) comment that pre-slaughter stress caused by fatigue, physical activity, fights, or any other activity that may overexcite broilers, without enough time to replenish glycogen, will cause early depletion of the muscle glycogen, resulting in limited muscle glycolysis after slaughter, high pH 24 hours *post mortem*, changes in meat color and tenderness after cooking, resulting in DFD (dark, firm and dry) meat.

Due to the increasing market demand for deboned parts and further-processed products, other factors began to worry researchers, such as the effect of fasting on meat quality in terms of pH, tenderness, cooking loss, and chemical composition (Ali *et al.*, 1999; Beraquet *et al.*, 1999; Berri, 2000).

Therefore, studies presenting alternatives to minimize the deleterious effects of pre-slaughter handling practices on the carcass and meat quality of broilers are necessary. Recent studies suggested that dietary vitamin E may be a promising alternative to improve such parameters. Vitamin E is a powerful antioxidant and its supply in diets has resulted in lower meat lipid oxidation and drip loss and better meat color (Souza *et al.*, 2007).

The addition of carbohydrates to the drinking water during feed withdrawal may be an alternative to prevent muscle glycogen depletion during this period. Studies have also been carried out for many years on the addition of electrolytes to broiler diets (Borges, 1997; Souza Junior *et al.*, 2006) with the purpose of promoting greater retention of fluids in the carcass. This practice aims at preventing muscle dehydration during the off-feed period in the poultry house, transport to the processing facilities and during lair age. In addition of reducing the occurrence of meat organoleptic problems associated with water loss (drip loss and cooking loss), it improves the visual aspect of meat and considerably increases its tenderness (Souza Júnior *et al.*, 2006).

This study aimed at evaluating the effects of the addition of different levels of glucose, sodium bicarbonate, and vitamin E to the drinking water of broiler chickens during the pre-slaughter feed withdrawal on carcass yield, organs weight and yield, gastric emptying, and meat quality.

MATERIAL AND METHODS

This studied was conducted at the experimental poultry house of La Salle agricultural college in Xanxerê, SC, Brazil. Broilers were managed according to commercial poultry farming practices and genetic company manual, including handling, pre-slaughter, loading, transport, and slaughter.

On the day before slaughter, feed was withdrawn and 500 42-day-old Cobb broilers received only water. These birds were distributed according to a completely randomized experimental design (Table 1) into 10 treatments with 10 replicates of five birds each. The following treatments were applied: water (control treatment); 50 g/L of glucose; 50g/L of glucose + 200mg/L of vitamin E; 75g/L of glucose; 75g/L of glucose + 200mg/L of vitamin E; 0.45% of sodium bicarbonate; 0.45% of sodium bicarbonate + 200mg/L of vitamin E; 0.55% of sodium bicarbonate; 0.55% of sodium bicarbonate + 200mg of vitamin E and 200mg/L of vitamin E.

Twelve hours preceding the feed withdrawal, the nutrients were administered in the drinking water, and for this purpose, all nipple buckets and hoses were adapted to allow estimating water consumption. During the 12 hours of the feed withdrawal period, continuous lighting was provided (artificial + natural light). In order to simulate pre-slaughter handling, the broilers were kept in the pens without food for

six hours, and after which water was withdrawn and they remained in the pens for one hour. Birds were then caught, placed into crates, and transferred to a controlled environment room at 32ºC and 65% humidity, where they remained for two hours (to simulate the heat stress that occurs in the hottest hours of the day during transport). Subsequently, the crates were transferred to another controlled environment room at 22ºC and 65% humidity, where the broilers remained for one hour (to simulate the environmental conditions of the lair age area in the processing plant. Birds were then insensibilizatedstunned and euthanized, totaling 11 hours of feed fasting.

The birds were weighed before bleeding, and after slaughter they were eviscerated, and the gizzard (full and emptied) was subsequently weighed to evaluate the relative gizzard weight and emptying.

The breast meat (*Pectoralis major)* was collected to assess meat quality, including pH, color, cooking loss, and shear force value. Meat pH value was measured, using a pH meter with a penetration electrode, 24 hours *post mortem* in samples stored at 4°C. The samples used for meat color evaluation were allowed to rest in a climatized room at 15°C for 30 minutes in order allow for the oxygenation of their surfaces, and color was then determined using a portable colorimeter (model MiniScan XE, Hunterlab), according to the scales L* (lightness), a* (redness) and b* (yellowness).

Samples submitted to cooking loss and shear force evaluation were wrapped in aluminum foil and placed in a commercial electric grill with cooking heat at the top and bottom, heated to a temperature of 170°C until reaching 82°C inner temperature (Novello *et al.*, 2009). Samples were weighed one hour after removal from the grill. Cooking loss was determined as the weight difference between the fresh and the cooked sample (Lyon *et al.*, 1998), and expressed in percentage. Shear force was measured in the cooked meat samples. The samples were placed with the fibers oriented perpendicularly to the blades of a Warner-Bratzler apparatus, coupled to a Instron M 2318 device, according to the procedure described by Froning *et al.* (1978)

Table 1 – Treatments used in the experiment

Treatment	NaHCO3/glucose	vit E (mg/L)
T1	Water (control)	
T5	50g/L of glucose	-
T6	50g/L of glucose	200mg/L vit. E
T7	75g/L of glucose	-
T8	75g/L of glucose	200mg/L vit. E
T1	0.45% of NaHCO3	-
T2	0.45% of NaHCO3	200mg/L vit. E
T3	0.55% of NaHCO3	-
T4	0.55% of NaHCO3	200mg/L vit. E
T9	-	200mg/L vit. E

Carcass yield and weight, relative organ weight, and meat quality data were subjected to the analysis of variance, and, when significant differences were detected, means were compared by the Student-Newmann-Keuls test at 5% significance level ($p<0.05$), using a statistical software.

RESULTS AND DISCUSSION

As shown in Table 3, there was no significant influence of the treatments applied in this study on full gizzard weight, emptied gizzard weight, or on the volume of feed present in the birds' gizzard. These results are in agreement with the findings of Borges (1997), Souza Junior (2006), and Denadai *et al.* (2002),

Table 3 – Full and emptied gizzard weights and feed content in the gizzard of broilers receiving different glucose, sodium bicarbonate, and vitamin E in the drinking water during the pre-slaughter feed withdrawal period.

Treatment	Full gizzard (g)	Emptied gizzard (g)	Feed content in gizzard (g)
Water (control)	56.40	46.00	10.40
50 g/L glucose	65.60	49.60	16.00
50 g/L glucose + 200 mg/L vit. E	61.40	48.80	12.60
75 g/L glucose	57.20	43.60	13.60
75 g/L glucose + 200 mg/L vit. E	69.40	51.40	18.00
0.45% $NaHCO_3$	65.40	49.00	16.40
0.45% $NaHCO_3$ + 200 mg/L vit. E	61.60	49.40	12.20
0.55% $NaHCO_3$	63.20	48.20	15.00
0.45% $NaHCO_3$ + 200 mg/L vit. E	58.60	45.80	12.80
200 mg/L vit. E	54.40	44.40	10.00
CV (%)	12.07	10.77	23.05
P	0.060	0.313	0.395

Means followed by different letters in the same column indicate significant difference ($p<0.05$) by the SNK test.

who assessed different times of feed withdrawal and did not detect any significant differences in gizzard contents. Denadai *et al.* (2002) obtained gizzard contents of10 to 19 g per broiler, which are close to those found in the present study. In addition, they did not find any significant differences in the contents of the crop, intestines or total digestive tract. In contrast, Schettino *et al.* (2006) observed a reduction in the gizzard contents of broiler chickens as the time of feed withdrawal increased, when evaluating fasting times ranging from 4 to 16 hours.

These findings may be explained by the fact that feed retention in the gizzard is mostly determined by feed particle size, with little or no influence of water or electrolyte intake.

No significant differences (p>0.05) were observed among treatments regarding the evaluated meat quality parameters (Table 4). The pH values of the *pectoralis major* muscle were not influenced by the treatments. These results are consistent with the findings described by Souza *et al.* (2006), who did not find any effect of the addition of 0, 100, 150, and 200mg of vitamin E/ kg of diet on chicken meat pH. Leonel *et al.* (2007) did not detect any significant differences in meat pH when adding vitamin E to broiler diets. According to Mendes (2001a), chicken meat finalultimatepH values after slaughter range between 5.7 and 5.9, corroborating the values found in the present study.

Cooking loss presented similar values (p>0.05) among treatments. In the study of Almeida (2008), testing the addition of different levels of vitamin E combined with linoleic acid to one- to 49-day-old broilers, no meat pH differences were found. Castro *et al.* (2008) also evaluated different pre-slaughter periods in broilers and obtained cooking losses between 25% and 30%, consistent with those found in the present study.

Shear force values were not different (p>0.05) in the breast meat of broilers supplemented with different nutrients. Lyon *et al.* (2004)fed broilers with diets based on corn and soybean meal, or wheat and soybean meal, and found values ranging between 1.82 and 2.19 kgf/cm^2, considering values between 1.60 and 3.0 kgf/cm^2 as those recommended for broiler breast, and their findings are close to those found in the present experiment. Additionally, Almeida (2008) did not find any variations in shear force breast and thigh meat values in 49-day old broilers supplemented with increasing levels of vitamin E.

There were no significant differences (p>0.05) in L* (lightness) color parameter. These results are consistent with those of Leonel *et al.* (2007) and Boschini (2011), who did not find any significant changes in breast meat lightness when using different levels of vitamin E. Castro *et al.* (2008) also did not find any differences in breast meat lightness when evaluating different off-feed times, and suggested that different periods of feed withdrawal do not influence this parameter. In contrast, Karacay *et al.* (2008) observed differences in meat lightness when supplementing sucrose, which is converted in glucose in small intestine, in the drinking water of broilers during pre-slaughter feed withdrawal, which is converted in glucose in small intestine,compared with glucose supplementation in the drinking water.

Table 4 – Meat quality of broiler chickens receiving different glucose, sodium bicarbonate, and vitamin E in the drinking water during the pre-slaughter feed with drawal period.

Treatment	pH	Cooking loss(%)	Shearforce (kgf/cm^2)	Color		
				L*	a*	b*
Water (control)	5.90	25.20	2.63	45.81	3.28	6.92
50 g/L glucose	5.84	27.48	1.89	49.31	2.68	8.70
50 g/L glucose + 200 mg/L vit. E	5.81	25.10	2.11	51.01	2.93	8.74
75 g/L glucose	5.89	25.95	2.21	46.81	3.53	7.41
75 g/L glucose + 200 mg/L vit. E	5.87	24.46	1.82	47.32	3.10	8.11
0.45% $NaHCO_3$	5.91	26.51	1.68	49.25	2.34	7.22
0.45% $NaHCO_3$ + 200 mg/L vit. E	5.87	24.60	2.03	46.14	2.64	8.44
0.55% $NaHCO_3$	5.90	20.76	2.48	48.85	3.22	8.91
0.45% $NaHCO_3$ + 200 mg/L vit. E	5.88	25.31	2.45	48.83	2.94	7.64
200 mg/L vit. E	5.91	26.61	1.82	46.34	3.86	7.79
CV (%)	1.33	12.80	24.90	7.32	9.90	20.61
P	0.436	0.394	0.375	0.063	0.312	0.080

Means followed by different letters in the same column indicate significant difference (p<0.05) by SNK test.

According to Barbut (1998), theme at-quality defect PSE is determined by combining pH values lower than 5.8 and lightness values (L* parameter) higher than 52, measured 24 hours after slaughter. Thus, broilers slaughtered according to current conventional standards may present low incidence of PSE meat, as in the present study all pH values were above 5.8, while L* values were below 52.

No significant a* value differences ($p>0.05$) were found among treatments. These results are consistent with those found and described by Leonel *et al.* (2007) and Boschini (2011), who did not find any meat redness differences when testing different dietary vitamin E levels in broilers. This parameter (pigmentation/redness) is used to assess myoglobin oxidation, with high redness values indicating high myoglobin oxidation.

Accordingly, there were no b* (pigmentation/yellowness) value differences ($p>0.05$) among treatments. Leonel *et al.* (2007) and Boschini (2011) also did not find any significant changes in this value. On the other hand, Karacay *et al.* (2008), adding sucrose to the drinking water during the pre-slaughter feed withdrawal period found higher lightness and redness values in the breast lives and liver.

CONCLUSION

The addition of glucose, sodium bicarbonate, and vitamin E to the drinking water of broiler chickens during pre-slaughter feed withdrawal had no influence on gizzard emptying of broilers subjected to pre-slaughter standard handling. Likewise, the addition of these nutrients has no impact on chicken meat quality.

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