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Broiler Welfare Evaluation Through Two Stunning Methods: Effects on Critical Blood Variables and Carcass Yield

[1]M.J. Maldonado, [2]D. Mota-Rojas, [3]M. Becerril-Herrera, [4]S. Flores-Peinado,
[5]D. Camacho-Morfín, [4]A. Cardona-Leija, [2]R. Ramírez-Necoechea,
[5]L. Morfín-Loyden, [2]M. González-Lozano, [6]M.E. Pereda-Solís and [2]M. Alonso-Spilsbury
[1]Tesista de la Licenciatura de Medicina Veterinaria y Zootecnia,
[2]Department Producción Agrícola y Animal,
Universidad Autónoma Metropolitana-Plantel Xochimilco, D.F., México
[3]EIAH-Benemérita Universidad Autónoma de Puebla, Teziutlán, Puebla, México
[4]Taller de Carnes, [5]Department de Ciencias Pecuarias,
Facultad de Estudios Superiores Cuautitlán, Campo 4,
Universidad Nacional Autónoma de México, Cuautitlán Izcalli, México. C.P. 54500
[6]Facultad de Medicina Veterinaria y Zootecnia de la Universidad,
Juarez del Estado de Durango, Durango, México

Abstract: The objective of this study, was to evaluate the effect of two stunning methods on blood gasometry, metabolic profile, acid-base balance and carcass quality on broilers. Sixty broilers were monitored. Before sacrifice, the birds were weighed and randomly divided by sacrifice method into 2 groups: decapitation (30) and electric stunning (30). Bleeding was timed and a blood samples were taken in order to evaluate critical blood parameters. The chickens remained 7 sec in the scalding bucket at a 33°C, carcass meat pH and temperature were measured warm, post thermal shock and cold. The pCO_2 was the highest value measured on the desensitized chickens using the electric stunning method and the pO_2 was higher on the decapitated birds. Even though no differences were noted, it is worth mentioning that glucose levels were higher than 200 mg dL^{-1} and lactate was extremely low (5 mg dL^{-1}) regardless of sacrificial method. Highly significant differences were observed in pre-shock pH and post shock values of the decapitated bird (from acid to neutral). We conclude that regardless of the sacrificial method, the physiological variables were not modified between groups, and therefore had no negative effects on the broiler carcass.

Key words: Blood gas, animal welfare, decapitation, electric stunning, carcass yield

INTRODUCTION

The production and consumption of broiler has increased considerably in Mexico (Richardson and Mead, 2001). Commercial broiler plants sacrifice from 140-180 chicken per minute, sometimes the chicken are not stunned properly, which makes manual sacrificing necessary (McNeal and Fletcher, 2003; McNeal *et al*., 2003). Handling before sacrifice depreciates the value of meat, due to hemorrhages, hematomas and broken bones, as well as undesirable discolorations and a decreased water retention capacity (McNeal *et al*., 2003). Hematomas are characterized by the presence of blood in the skin tissue and are the result of trauma; both hematomas and hemorrhages are unpleasant to the eye and decrease the price of meat, most are not detected in living birds and are only visible during the first phases of sacrifice after feather removal (Warris *et al*., 1993). As time goes by the blood on the wounded tissue oxidizes and the color darkens, passing from a red to a darker red or purple and later turns green or yellow. The carcass meat bruises change to a dark red purple (Prandl, 1994).

Today in Mexico quality carcass meet is not paid for. PSE and DFD are the same price, it does not matter if the pH descends drastically or not, if the animals were stressed or if any welfare regulations were followed.

Corresponding Author: D. Mota-Rojas, Department Producción Agrícola y Animal, Universidad Autónoma Metropolitana, Plantel Xochimilco, Calzada del Hueso 1100, Col. Villa Quietud, CP04960 México D.F. México.

When the neck is not properly cut some birds will enter the scalding tank before they are dead, and some may display obvious signs of consciousness. As only a certain proportion of broilers are killed in the stunner, it is vital that neck cutting should be efficient so that the other birds die as quickly as possible, thereby minimizing the risk of their regaining consciousness during bleeding out. However, neck cutting is nearly always not efficient, and some broilers do indeed regain consciousness during bleeding out. A cardiac arrest should be induced at stunning to avoid the problems associated with inefficient neck cutting, which are only too common in poultry processing plants (Gregory and Wilkins, 1990). The distress grade causes maladjustment, before and during the sacrifice of the bird for energetic metabolism as well as an imbalance in base acid. So far, there are no studies on blood gasometry, acid base imbalance, metabolic profile and the correlation of these chemical indicators on the quality of the meat from warm or cold broiler carcasses. Thus, the objective of this study, was to evaluate the effect of the sacrificing method on blood gasometry, acid base equilibrium, metabolic profile, sacrifice and the quality of warm or cold carcass meat on broilers.

MATERIALS AND METHODS

To evaluate alterations in acid-base equilibrium, metabolic profile, characterization and evaluation of warm and cold broiler carcass quality, sixty broiler chickens were used. Before sacrificing, all birds were weighed on a digital scale (Tor-Rey®) and randomly divided into two groups, 30 were sacrificed by decapitation and 30 by electric stunning. For electric stunning, clips with electric current were used that varied from 100-120 mA/bird for 4 sec. The carotid artery and jugular vein were cut immediately afterwards. At the time of bleeding, body temperatures were recorded with a laser thermometer (Deltatrack®); the time of bleeding was recorded by one of the investigators using a chronometer (90 sec to 1 min $bird^{-1}$). During bleeding, samples were taken in order to evaluate the following critical blood parameters: a blood gas analyzer was used to measure pH, concentrated glucose, lactate, pCO_2 pO_2, HCO_3, hematocrit, oxygen saturation, excess of base and electrolytes (GEM Premier 3000®, Instrumentation Laboratory Diagnostics S.A. de C.V. Mexico).

After bleeding, the birds were put in a scalding tank, which had a temperature of 33°C, constantly measured with a digital bayonet thermometer (Model N. 31308- KC). The birds remained in the scalding tank for 7 sec $bird^{-1}$. Later they were sent to the feather removal room where the head, legs and neck were chopped. At the time of gutting all green organs were removed (intestines, giblet, proventricular) and red organs (heart, liver); weight was obtained separately with a digital scale (Ohaus Explorer®), then the birds were washed and bagged and warm carcasses were weighed.

Carcasses were washed and then temperatures were taken with a digital bayonet thermometer (Model N. 31308-KC, Type K Thermocouple, Atkins Technical, Inc. Gainesville, Flo. USA). The pH was measured with a special potentiometer for meat (Hanna instruments HI 8314 membrane pH meter), which was previously calibrated with a buffer solution (pH 4 and pH 7). All measurements were taken from the right pectoral muscle and the right bicep. Carcasses were placed in a bucket with ice provoking thermal shock, then pH was measured again with the same meat potentiometer. Carcasses were kept in a cold chamber for 12 h, temperature and pH were measured with the before mentioned equipment. Measurements were always taken from the large pectoral muscle and the right bicep, finally the weight of the cold carcasses were measured.

Statistical analysis: In order to evaluate differences between blood gasometry indicators, response variables were analyzed using a completely random design with the following statistic model:

$$Y_{ij} = \mu + \iota_i + \xi_{ij}$$

Where:

Y_{ij} = Response variable
μ = General average
ι_i = Treatment effect
ξ_{ij} = Random error
i = 1, 2, 3, treatments
j = 1, 2, 3... 50 repetitions

To determine significant differences between group readings a Tukey test was used ($p<0.05$), the pH indicator was analyzed using a statistic Kruskal-Wallis test. The SAS program version 6.12 (1997) was used for all statistic analysis.

RESULTS

The average and error for metabolism indicators, gas pressure and blood pH on desensitized chickens using two different methods, is provided in Table 1. The only significant variables were observed for pCO_2 and pO_2 when compared between the two methods, the pCO_2 value was higher on chickens desensitized with the electric method, and as was expected, the pO_2 value was less for these birds. This indicates that the blood gas values were affected, depending on the desensitizing method.

Table 1: Mean and standard error of the mean for metabolic variables, gas pressure and blood pH in both methods of desensitization

Variables	Decapitated chicken n =27 Mean±SEEM	Electric stunning chicken n =28 Mean±SEM	P(α)
pH	7.44±0.011	7.41±0.01	0.2837*
pCO_2 (mmHg)	29.25±0.89	32.67±0.78	0.0054
pO_2 (mmHg)	49.62±1.78	36.67±1.31	0.0001
Na^+ (mmol/L)	147.07±0.47	147.35±0.58	0.7084
K^+ (mmol/L)	4.93±0.13	5.00±0.12	0.6940
Ca^{++} (mmol/L)	1.38±0.01	1.39±0.01	0.5535
Glucose (mg/dL)	218.18±4.46	222.82±4.16	0.4509
Lactate (mg/dL)	5.96±0.40	5.82±0.35	0.7897
Hematocrite (%)	32.03±0.62	32.03±0.78	0.9990

*Statistically analyzed with a Krukal-Wllis test

Table 2:Mean and standard error of the mean on pH variables and *Pectoralis* muscle temperature for chickens in both methods

Variables	Decapitated chicken n =30 Mean±SEM	Electric stunning chicken n =30 Mean±SEM	P(α)
pH pre shock	6.40±0.05	6.79±0.04	0.0001
Pre shock temperature (°C)	37.35±0.83	36.75±0.88	0.6112
Post shock pH	7.09±0.64	6.79±0.05	0.0001
Post shock temperature (°C)	23.85±0.67	24.70±0.38	0.7418
Cooling pH	6.27±0.02	6.22±0.01	0.0768
Cooling temperature (°C)	6.30±0.13	6.23±0.11	0.9441

Table 3: Mean and standard error of the mean for pH variables of the femoral Bicep muscle using both methods

Variables	Decapitated chicken n =30 Mean±SEM	Electric stunning chicken n =30 Mean±SEM	P(α)
pH pre shock	6.62±0.04	6.89±0.05	0.0005
Pre shock temperature (°C)	32.51±1.53	32.45±0.95	0.2298
Post shock pH	7.07±0.49	6.76±0.04	0.0173
Post shock temperature (°C)	22.59±0.65	23.30±0.33	0.5254
Cooling pH	6.70±0.06	6.65±0.03	0.0044
Cooling temperature (°C)	5.48±0.18	5.60±0.11	0.9441

Table 4: Mean and standard error of the mean for carcass and offal weights of desensitized broilers in both methods

Variables	Decapitated chicken n =30 Mean±SEM	Electric stunning chicken n =30 Mean±SEM	P(α)
Live weight (g)	2571.66±32.62	2557.16±45.90	0.7978
Hot carcass weight (g)	1821.60±24.57	1775.16±34.77	0.2805
Cold carcass weight (g)	1898.60±24.99	1890.80±31.98	0.8483
Leg weight (g)	101.15±1.82	102.48±2.15	0.6411
Heart weight (g)	13.85±0.37	13.70±0.39	0.7819
Liver weight (g)	49.32±1.25	47.99±1.36	0.4761
Internal organ weight (g)	118.80±4.52	19.80±3.79	0.8660
Gizzard weight (g)	37.27±1.21	38.74±1.19	0.3914
Neck and head weight (g)	112.36±2.72	18.34±3.59	0.1906
Sacrifice temperature (°C)	32.34±0.36	31.51±0.59	0.2419
Blood pH	7.43±0.01	7.41±0.01	0.2853
Bleeding time (min)	1.40±0.13	1.56±0.15	0.4222

Although no differences were observed, it is worth mentioning that the glucose values were higher than 200 mg dL^{-1} and lactate was extremely low (5 mg dL^{-1}), regardless of the sacrificial method used.

The temperature values and *Pectoralis* muscle pH recorded at different times during the sacrificial process using both methods are presented in Table 2. Highly significant differences were observed between decapitated and electrocuted broilers for pH values, these differences are more notable in the evaluations performed pre shock and post shock. Particularly pH values of decapitated chickens which changed from acid to neutral in approximately 60 min, this phenomena was not observed on birds desensitized by the electric method.

The temperature and pH of the bicep femoral muscle recorded at different times during the sacrificial process are shown in Table 3. The differences between both methods of desensitizing were similar to that which is observed in the pH pectoral muscle variable. Nevertheless pH values did not decrease much after refrigeration, probably due to the type of muscle, its activity and size. In Table 4, we observed that neither of the two

desensitizing methods had any effect on carcass or organ weight of the birds. The weights of the hot carcasses were between 1,775 and 1,821 g, the hot carcasses yield was 70.8 and 69.41% for the group of decapitated chickens vs. stunned chickens, respectively.

DISCUSSION

We observed in this study that broilers desensitized with the electric method were subjected to acute stress that affected the values for pH, post shock temperature and even bleeding time. When animals are exposed to stressful factors, hormone secretion coming from the cortex and adrenal medulla automatically increases and modifies muscular and hepatic glucose concentration. Alteration of glucose in muscle may affect color and other meat quality attributes after sacrifice, since it is directly related to the final pH (Sams, 1999). Agitated birds exposed to stressful conditions before or during sacrifice use the glucose they have left and muscles consume energy quickly, which accelerates the state of rigor mortis and has a negative affect on meat softness (Ramos, 2005).

During this experiment we observed pH values change from acid to neutral for decapitated chickens approximately 60 min, a fact that was not observed for desensitized birds with electric stunning. The pH of the muscle while live is 7.2, after death the muscle acidifies with values up to 6, due in part to the accumulation of lactic acid resulting from the degradation of the glycogen caused by post mortem glycolysis, in a process that liberates energy in the form of an Adenosine Triphosphate (ATP) (Richardson and Mead, 2001). The relation between speed and change in pH and the final quality of the meat (understood as final water retention capability, color and strength) is directly related to the temperature of the muscle when it reaches a pH of 6.0. Rapid decrease of pH is produced when temperature rise, causing early rigor mortis and a higher grade of shortening because of rigor (Sams and Janky, 1991). Metabolism of muscle immediately defines poultry quality post mortem, this can be modified by external and environment factors. A study conducted by the veterinary science department at West Virginia University, compared two methods of stunning: kosher bleeding vs. electric stunning, in order to test the effect of the pH variations and muscle quality. Investigators concluded that electric stunning increased softness of meat and improved the color of broiler breast.

Stunning methods have a considerable impact carcass meat quality and depending on the method, may cause hemorrhage (breaking blood vessels), broken bones and decreased water retention. Therefore, it is important to take note of some anatomic and physiological characteristics of stunning. For example; the muscles in the breast, superficial pectoral (major pectoral) and supracoracoideus (minor pectoral) muscles, which are the most valuable parts of the poultry body. Both muscles are made up of quick contraction glycolytic fibers (>90%), as well as enzyme activity in ATP-ase white fibers which is faster compared to red fibers, resulting in the following:) Muscles capable of decreasing pH faster or developing post mortem rigor mortis) tension produced in response to nerve stimulation of rapid contraction white fibers that take 7.5 min to contract, compared to the slow contraction red fiber (100 min) (Richardson and Mead, 2001).

Gregory and Austin (1992), observed that a voltage boost from 60-110 mA, increased the incidence of ventricular fibrillation from 20-99%, not permitting the chicken to recover from the electrical process, so that they would expire after the electric process was induced as well as cutting and bleeding. It is well known that high amperage has a greater effect on deteriorating breast muscle characteristics, causing hemorrhages and increasing broken bones (Craig and Fletcher, 1997). Craig *et al.* (1999) determined that high amperage slowed the development of rigor mortis approximately 6 h, compared to chickens stunned with 50 mA which had lower pH values in muscles and breasts with higher values than chicken stunned with 125 mA. According to Gregory and Austin (1992) the purpose of stunning with high voltage is to produce epilepsy in the chicken's brain, this is obtained through an encephalogram, nevertheless they observed that higher current increases incidence of broken wings and bones, dislocations, deep breast muscle hemorrhages and congestion in wing veins. The increasing effect of higher electrical currents on the incidence of broken bones was observed by Gregory and Wilkins (1990). During conventional water bath stunning, electrical current passes through the whole body, causing muscle contraction, broken bones, and breast muscle hemorrhages.

The usage of high frequency electric stunning followed by decapitation has shown to have side effects on the quality of carcass (McNeal and Fletcher, 2003). These authors mention that high frequency electric stunning followed by conventional cutting of the neck eliminates muscular contractions post mortem regularly observed in development of rigor mortis and affect the quality of meat. Craig *et al.* (1999) pointed out that electric stunning can delay post mortem glycolysis or reduce accumulation of lactic acid, besides slowing resistance

ante and perimortem. Sams (1999) suggests that post mortem electric stimulation could have some commercial use, in recent work he has demonstrated that electric stunning slows the process of rigor mortis. It is interesting that electrical stunning before death of the bird slows development of rigor mortis, while electric stimulation post mortem accelerates development of rigor mortis (Craig *et al*., 1999).

CONCLUSION

In conclusion, the pH values showed interesting differences between desensitizing methods; such values must be considered in future studies to evaluate meat quality when different poultry sacrifice methods are used. It is important that the birds are desensitized and bled immediately, making an effort to minimize manual or mechanical handling, this will decrease the stress inflicted on birds, wounds on skin and tissue or any other damage. This study shows that regardless of the sacrificial method used, the physiological variables were not modified among groups, and therefore there were no negative side effects on bird carcass. Nevertheless, animal welfare is very important and blood gases values´ showed to be a good indicator to prove both methods desensitizing effectiveness, guaranteeing that birds have been sacrificed with minimum suffering and stress. The birds desensitized with the electrical method were subjected to extreme stress that affected final pH values.

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