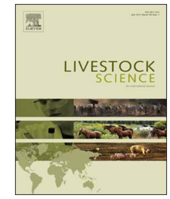
Livestock Science 205 (2017) 16–23

Contents lists available at ScienceDirect

Livestock Science

journal homepage: www.elsevier.com/locate/livsci



The effects of pre-transport supplementation with electrolytes and betaine on performance, carcass yield and meat quality of broilers in summer and winter

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ARTICLE INFO

Keywords:
Broilers
Electrolytes
Betaine
Temperature
Meat quality

ABSTRACT

The consequences of high ambient temperature for broiler chickens collectively results in poorer productivity, prostration and even death. As they approach processing weight, broilers are particularly sensitive to heat stress as they produce large amounts of metabolic heat. Transport from farm to the processing site is a stress for broilers. So, the combination of high ambient temperature prior to transport and the stress associated with transport to processing have unwanted effects on broiler performance and meat quality.

In two experiments (summer and winter) the effect of supplementing the water of Ross-308 broiler chickens with electrolytes, with or without betaine for 2 days before processing, on performance and breast muscle meat quality were investigated. In the summer experiment broilers were exposed to a cyclic high temperature protocol over the two days (9 h at 28–29 °C and 14 h at 22–24 °C). In the winter experiment the shed temperature ranged between 14 and 18 °C. The growth performance of birds during supplementation and then the breast muscle meat quality 24–72 h post-mortem were determined.

In both experiments betaine had no effect on any performance or meat quality measure and the electrolyte supplementation had no effect on growth performance. In the summer experiment, electrolyte supplementation had significant effects on some measures of meat quality. Breast muscle from supplemented birds had lower 24 h post-mortem pH and based on meat 'lightness', lower levels of PSE meat. The 72 h drip loss was significantly lower in meat from birds that had been supplemented with electrolytes. The electrolyte supplements had no effects on meat 'redness' or 'yellowness', on shear force or cooking losses.

In the winter experiment, the electrolyte supplementation had no effect on growth performance or breast muscle meat quality. In this experiment, the average shed temperature was approximately 16 °C with peak values of approximately 18 °C. The growth rate of the birds was approximately 40% higher than that identified in industry performance standards for the Ross-308 strain. The data suggest that the temperature for best performance of the Ross-308 is lower than the 18–24 °C currently accepted as ideal.

In all experiments there were significant effects of bird gender on performance and meat quality measures.

While electrolyte supplementation supported improvements in meat quality during periods of moderately high ambient temperature, the commercial benefit of these would need to be assessed. The value of electrolyte supplementation is likely to be more substantial when broiler chickens experience heat wave conditions with temperatures > 32 °C, but this remains to be evaluated.

1. Introduction

The rapid growth rate and the associated production of metabolic heat, makes the modern broiler highly susceptible to heat stress, which the poultry industry manages through shed design, cooling and ventilation systems to help manage shed temperatures. However, during heat wave conditions in summer, broiler chickens can still experience temperatures well in excess of their thermo-neutral zone. Heat stress in broiler chickens is associated with depressed feed intake, poorer feed efficiency, reduced growth rates, and can result in higher mortality (Mitchell and Carlisle, 1992; Koh and Macleod, 1999; Sayed and Downing, 2011, 2015). The problems related to heat stress can be exasperated during the process of transport to processing. The combination of high temperature days before slaughter, when birds are most

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http://dx.doi.org/10.1016/j.livsci.2017.09.006
Received 31 May 2017; Received in revised form 5 September 2017; Accepted 8 September 2017

susceptible to heat stress, and the stresses of transport to processing can increase weight loss, reduce carcass yield and meat quality (Donkoh, 1989; Aksit et al., 2006).

Electrolyte supplementation in feed or water has been used to combat the adverse effects of broiler heat stress (Teeter et al., 1985; Smith and Teeter, 1989; Benton et al., 1998; Ahmad et al., 2006; Sayed and Downing, 2011, 2015). Electrolyte salts commonly used in water include sodium chloride, sodium bicarbonate and potassium chloride (Teeter et al., 1985; Smith and Teeter, 1993; Deyhim and Teeter, 1995; Ahmad et al., 2006).

Betaine (trimethylglycine) is used as an organic osmolyte in poultry diets (Kidd et al., 1997). Tissues that utilise betaine as an osmolyte include the intestine, kidney, liver, brain and leukocytes (Klasing et al., 2002). Under certain circumstances, such as dehydration and diarrhoea, organic osmolytes can act to reduce water loss under conditions of high osmotic pressure (Klasing et al., 2002). There is evidence that betaine supplementation (1000 mg/kg) in broiler diets can improve growth rates by approximately 7% (Zhan, 2000).

Transport from the farm to the processing site is a stressor for broiler chickens (Nicol and Scott, 1990). The combination of high ambient temperature prior to transport and the stress associated with the transport process have unwanted effects on the bird performance and meat quality (Simoes et al., 2009; Zhang et al., 2012; Yalcin and Güler, 2012). During transport and lairage, broiler chickens have no access to water and experience varying degrees of dehydration, which can reduce meat quality and importantly, is a welfare concern (Knowles et al., 1996; Elrom, 2001; Manning et al., 2007).

The aim of the research outlined here was to determine the effect that electrolyte supplementation in the drinking water prior to processing had on the performance and meat quality of broiler chickens. The performance and breast muscle meat quality were determined in two experiments one in summer and one in winter. The chickens were exposed to high ambient temperature in the summer experiment and moderately low temperature in the winter experiment.

2. Materials and methods

All experimental procedures were approved by the University of Sydney Animal Ethics Committee (Protocol: 2015/885) and complied with the Australian Code for the Care and Use of Animals for Scientific Purposes (National Health and Medical Research Council, 2004).

2.1. Birds and feeding

Day old feather sexed Ross-308 broiler chickens were obtained from a commercial hatchery. Chickens were reared in floor pens, in a tunnel ventilated shed, as individual sexes for the first four weeks of age. Supplementary heat was provided during the first 3 week brooding period. After this all efforts were made to maintain the shed temperature at 20 °C. At 29 days of age, equal numbers of males and females were allocated to treatment pens so that at 45 days of age the floor space would be equivalent to 30 kg liveweight/m^2. Pens had individual water sources.

The birds were fed a starter (days 1–14), grower (days 15–28) and finisher (days 29–45) diets, provided as pellets. The diet formulations and estimated nutrient composition are given in Table 1.

Table 1
The diet formulations and calculated nutrient concentrations.

Components	Starter diet	Grower diet	Finisher diet
Wheat	57.43	62.69	68.57
Soybean meal	31.30	22.93	16.14
Canola meal	6.00	7.00	8.00
Vegetable oil	2.02	4.49	4.62
Sodium Chloride	0.17	0.14	0.14
Limestone	0.99	0.88	0.87
Di-Calcium Phosphate	1.04	0.82	0.65
Lysine	0.21	0.26	0.25
DL-Methionine	0.29	0.22	0.17
Threonine	0.08	0.07	0.06
Sodium Bicarbonate	0.24	0.30	0.31
[a]AXTRA XB 201	0.01	0.01	0.01
[b]AXTRA PHY 5000	0.01	0.01	0.01
[c]Premix	0.20	0.02	0.02
Calculated composition			
AME (MJ/kg)	11.9	12.66	12.83
Protein (%)	22.87	21.30	19.35
Fat (%)	4.00	6.50	6.71
Starch (%)	35.30	38.26	41.63
Lysine (%)	1.38	1.24	1.08
Methionine (%)	0.63	0.54	0.47
Available P (%)	0.42	0.38	0.35
Calcium (%)	0.85	0.75	0.70

[a] AXTRA XB 201 - Xylanase and beta-glucanase enzyme combination (Danisco Animal Nutrition, Marlborough, Wiltshire, United Kingdom).

[b] AXTRA PHY 5000 – Phytase enzyme (Danisco Animal Nutrition, Marlborough, Wiltshire, United Kingdom).

[c] The vitamin mineral premix provided the following (per kg of diet): vitamin A, 10,000 IU; Vitamin D3, 2500 IU; Vitamin E, 30 mg; vitamin K_3, 2 mg; vitamin B_1, 1.5 mg; vitamin B_2, 8 mg; Vitamin B_6, 4 mg; vitamin B_{12}, 0.02 mg; calcium pantothenate 15 mg; folic acid, 2 mg; niacin, 45 mg; biotin, 0.135 mg; cobalt sulphate, 0.2 mg; copper sulphate, 6 mg; ferrous sulphate, 50 mg; potassium iodine, 0.75 mg; manganous oxide, 0.075 mg; selenium selenite, 0.15 mg; zinc oxide, 60 mg.

2.2. Treatments and performance measures

The electrolyte supplement consisted of sodium chloride (157 g), sodium bicarbonate (171 g) and potassium chloride (88.4 g) dissolved in 100 L of mains tap water. The betaine (Betafin® Natural Betaine; Danisco Animal Nutrition, Marlborough, Wiltshire, United Kingdom) was added to the electrolyte solution at 40 g per 100 L.

2.2.1. Experiment 1 (summer)

There were eight replicate pens for each of the three treatments with 10 males and 10 females in each replicate (total = 480). The shed was divided into four blocks with 2 pens of each treatment allocated randomly to each block. Chickens in the control group received mains water only. The remaining treatment groups were provided with the electrolyte supplemented water alone or the electrolyte supplement plus betaine. On day 43 of age, the chickens were weighed and then at 16:00 h provided with their respective treatments. On days 44–45 of age, the day (08:30–17:30 h) temperature of the shed was raised to 32 °C and then reduced to 22 °C during the night (17:30–08:30 h). When it was observed that the birds had difficulty handling the high day temperature the maximum temperature was limited to 28 °C. Feed and fluid intake was determined on a pen basis over the high temperature treatment period.

2.2.2. Experiment 2 (Winter)

The treatments were the same as detailed for Experiment 1, except the supplements were supplied over days 45–46 of age to align with the availability of the processing facility. The only temperature control in this experiment was to limit the shed temperature to a maximum of 20 °C from week 4 until processing.

As part of the animal ethics protocol, strict guidelines were set for the removal of birds from the summer experiment during the high temperature treatment period. Birds were removed when it became obvious that their continuous presence in the high temperature would most likely result in their possible death.

2.3. Transport and processing

At day 45 for the summer experiment and day 46 for the winter experiment, between 20:00–22:30 h, all chickens were individually