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Effects of Adding Vitamins and Organic Acids into the Drinking Water on Growth Performance, Carcass Yield and Meat Quality of Broilers Raised Under Tropical Condition

Pornpun Phoprasit, Chaiyapoom Bunchasak, Choawit Rakangthong and Theerawit Poeikhampha
Department of Animal Science, Faculty of Agriculture, Kasetsart University,
Bangkok, 10900, Thailand

Abstract: Above-normal temperatures and humidity levels limit the productivity as well as aggravate the survival rate of broilers raised under tropical conditions. This study was conducted to evaluate the effects of adding vitamins and organic acids into the drinking water on the growth performance, carcass yield and meat quality of broilers raised under hot environmental conditions. A total of 1,500 broilers were divided into 5 groups and distributed into 6 pens with each pen consisting 50 birds following a Completely Randomized Design technique. Throughout the 42 days of the feeding trial, all birds received 5 types of drinking water as follows: No vitamins nor organic acids added (control), vitamin C added at 40 mg L^{-1} water; vitamins C and E added at 40 mg and 85 mg L^{-1} water, respectively. A complete mixture of various vitamins at 1 g L^{-1} and a complete mixture of various vitamins, plus 1 g organic acids, added at 1 mL L^{-1} water. Feeding and flock management were done in accordance with commercial practices. During the 42 days of experiment, the average lowest and highest temperatures were 27.21±1.16 and 34.12±1.15°C, respectively. The results indicated that birds given vitamin C in the drinking water had trended higher body weight and lower mortality rate. When vitamins C and E mixture was combined with organic acids and was added into the drinking water, the increase in body weight was highly significant ($p<0.01$). The visceral organs of the birds likewise increased. Furthermore, the drip loss percentage of the broilers significantly decreased. So, a combination of vitamins C and E mixed together with organic acids can result in improved growth performance and better meat quality in broilers raised under tropical conditions.

Key words: Vitamins, organic acids, drinking water, broiler, tropical condition

INTRODUCTION

Raising poultry under hot and tropical environment can render the birds highly susceptible to environmental stress. The prevailing high ambient temperature, exacerbated by intensive rearing practices, almost always impacts negatively on the production performance and health of animals (Ayo *et al*., 1996). Heat stress induces production of more free radicals that not only cause damage in cells but also result in diminished meat quality (Njoku, 1986). Thailand, one of the world's leading broiler producers, has a tropical environment where ambient temperature is around 30-35°C. Heat stress is therefore a management problem that must be dealt with accordingly. Cooling the birds' houses is not a viable option considering the additional costs such move entails. Ordinary broiler producers are thus left with no alternative but resort to dietary manipulations in order to alleviate the impact of high environmental temperature on the performance of their flocks.

Vitamins, together with trace minerals, are routinely added to poultry feeds in the form of premixes. The usual practice is to add the premixes at various levels depending on the growth stage and also following the recommendation of the manufacturers. Deviations, however, occur when the situation is not ordinary such as when humidity and prevailing temperature are quite high. Higher than usual levels of vitamins are also supplemented when there is a disease outbreak or whenever the health condition and the performance level of the birds so demand (Chunshan *et al*., 2006).

Under normal commercial operations, it is not common to alter the level of inclusion of vitamin-mineral premixes in the feed. This is because feeds are mixed in bulk quantities. Alternately, whenever there is a need for micronutrient supplementation, this is done through the drinking water. For one, birds have access to drinking water at all times throughout the day. Williams (1996)

Corresponding Author: Theerawit Poeikhampha, Department of Animal Science, Faculty of Agriculture, Kasetsart University, Bangkok, 10900, Thailand Tel/Fax: +66 2579 1120

reported that in broilers, the feed to water consumption ratio is 1.8:2.2. This means that the birds consume morewater than feed on a weight-by-weight basis. It appears, therefore, that supplementing micronutrients, e.g., vitamins and organic acids, via the drinking water can be an effective alternative to provide the birds extra nutrients to maintain good performance especially during unusual conditions (Skinner *et al*., 1991).

This study was conducted with the main objective of evaluating the effects of adding vitamins and organic acids into the drinking water on the growth performance, carcass yield and meat quality of broilers raised under tropical conditions.

MATERIALS AND METHODS

This study was conducted at the Animal Research Farm, Department of Animal Science, Faculty of Agriculture, Kasetsart University, Thailand. The experimental animals were kept, maintained, treated and handled in adherence and in accordance to accepted standards for the humane treatment of animals.

Animals and management: One thousand and five hundred day-old male chicks (Arbor Acres strain) were obtained from a commercial hatchery. The birds were randomly assigned according to their initial body weights to one control and 4 treatment groups. Each group was replicated into 6 pens with each pen consisting of 50 birds. The birds were given the same management and vaccination program as those done in commercial farms. Water and feed were provided *ad libitum* throughout the experiment. The water supply in each pen was equipped with bell from 1-10 days and nipple from 11-42 days. The birds in the control group received the basal diet and water (without any supplementation). The rest of the treatments were given the basal diet and their drinking water was supplemented with (1) Vtamin C at 40 mg L^{-1} (2) Vitamin C 40 mg L^{-1} combined with vitamin E (Lutavit® E 50S, BASF, Germany) at 85 mg L^{-1} (3) A complete mixture of various vitamins at 1 g L^{-1} (4) A complete mixture of various vitamins 1 g plus organic acids at 1 mL L^{-1} (Lupro-Mix® NC Liquid, BASF, Germany).

One kilogram of the complete mixture of various vitamins provides the following: vitamin A 2.50 MIU, vitamin D_3 1.00 MIU, vitamin E 85 g, vitamin K_3 0.80 g, vitamin B_1 1.80 g, vitamin B_2 2.50 g, vitamin B_6 1.80 g, vitamin B_{12} 0.01 g, pantothenic acid 10.00 g, niacin 20.00 g, folic acid 0.30 g, biotin 0.03 g, vitamin C 40.00 g, potassium 2.00 g, vitamin C 40 g, preservatives 10 g. The carrier added brings the total 1.00 kg.

Table 1: Feed ingredients and nutrients composition of the experimental diet

Items	Feeding period		
	Starter[1]	Grower[2]	Finisher[3]
Ingredients			
Yellow corn	51.94	56.17	61.37
Rice bran oil	3.23	4.57	4.57
Soybean meal (48% CP)	36.62	32.76	27.91
Full-fat soybean meal	3.00	2.00	2.00
Monodicalciumphosphate (21% P)	2.17	1.91	1.76
Salt	0.22	0.23	0.23
L-Lysine	0.25	0.16	0.10
DL-Methionine	0.38	0.31	0.24
L-Threonine	0.08	0.04	0.01
Premix[1,2,3]	0.50	0.50	0.50
Anticoccidial	0.05	0.05	0.05
Antioxidant	0.05	0.05	0.05
Calcium carbonate	1.50	1.25	1.21
Total	100.00	100.00	100.00
Nutrients (Calculation)			
Protein (%)	23.00	21.00	19.00
Energy (ME_kcal kg^{-1})	3,025.00	3,150.00	3,200.00
Fat (%)	5.97	7.23	7.38
Calcium (%)	1.05	0.90	0.85
Avail. phosphorus (%)	0.50	0.45	0.42
Salt (%)	0.28	0.28	0.28
Lysine (%)	1.43	1.24	1.06
Methionine + Cystine (%)	1.07	0.95	0.83
Methionine (%)	0.72	0.63	0.54
Threonine (%)	0.94	0.83	0.72
Tryptophan (%)	0.28	0.26	0.23
Arginine (%)	1.52	1.38	1.24

Premix[1], provided/kg of diet: vitamin A 11,000 IU, vitamin D_3 5,000 IU, vitamin E 75 IU, vitamin K_1 3 mg, vitamin B_1 3 mg, vitamin B_2 8 mg, niacin 60 mg, pantothenic acid 15 mg, pyridoxine 4 mg, folic acid 2 mg, biotin 0.15 mg, choline 1,600 mg, vitamin B_{12} 0.016 mg, Mn 120 mg, Zn 100 mg, Cu 16 mg, Selenium 0.30 mg, I 1.25 mg, Fe 40 mg. Premix[2], provided/kg of diet: vitamin A 9,000 IU, vitamin D3 5,000 IU, vitamin E 50 IU, vitamin K_1 3 mg, vitamin B_1 2 mg, vitamin B_2 6 mg, niacin 60 mg, pantothenic acid 15 mg, pyridoxine 3 mg, folic acid 1.75 mg, biotin 0.10 mg, choline 1,500 mg, vitamin B_{12} 0.016 mg, Mn 120 mg, Zn 100 mg, Cu 16 mg, Se 0.30 mg, I 1.25 mg, Fe 40 mg Premix[3], provided/kg of diet: vitamin A 9,000 IU, vitamin D3 4,000 IU, vitamin E 50 IU, vitamin K_1 2 mg, vitamin B_1 2 mg, vitamin B_2 5 mg, niacin 40 mg, pantothenic acid 15 mg, pyridoxine 2 mg, folic acid 1.5 mg, biotin 0.10 mg, choline 1,400 mg, vitamin B_{12} 0.010 mg, Mn 120 mg, Zn 100 mg, Cu 16 mg, Se 0.30 mg, I 1.25 mg, Fe 40 mg

One liter of the organic acids combination (Lupro-Mix® NC Liquid, BASF, Germany) consists of 380 g propionic acid, 80 g ammonium, 340 g formic acid. The carrier added makes the total 1.00 kg.

All the birds were fed a starter diet until 10 days of age, followed by a grower and finisher diets from "11-21" days and "22-42" days of age, respectively. The feed ingredients used and the nutritional composition of the experimental diets are shown in Table 1. The diets were formulated to meet the recommended nutritional requirements of the Arbor Acre broiler strain used. They contained 23% CP and 3,025 ME kcal kg^{-1} during the starter period, 21% CP and 3,150 ME kcal kg^{-1} during the grower period and 19% CP and 3,200 ME kcal kg^{-1} during the finisher period. The experiment was conducted during the months of September to November, 2012 in Bangkok, Thailand. Throughout the duration of the experiment, house temperature and humidity readings were taken and recorded four times a day (07.00, 12.00, 17.00 and 22.00).

Growth performance: Body weight, feed intake and flock mortality in each pen were recorded during all the feeding stages. Mean body weight, weight gain and feed intake were computed in order to determine Feed Conversion Ratio (FCR).

Carcass yield measurements: When the experiment ended on the 42 days, 12 birds were randomly chosen from each group and were asphyxiated using CO_2 under an atmosphere of less than 2% oxygen (air displaced by CO_2). The hot carcasses were manually eviscerated and weighed thereafter. These were then chilled and again, weighed. Abdominal fats were manually removed and weighed. The weights (±0.01) of the liver, heart, spleen, emptied gizzard and abdominal fats were each determined as a percentage of the body weight. Carcass weight was used as the basis in computing the dressing percentage.

Meat quality measurements: Meat quality was evaluated with a pH meter 45 min post mortal. After being chilled at 4°C for 24 h, breast meat pectoralis major (p. major) of the left side was examined for meat quality following Zhang *et al*. (2009). Color changes after refrigerated storage were measured on the freshly cut surface of sample by using Chroma Meter to record L*, a* and b* values. Breast meats were hung on a hook in the refrigerator for 48 h at 4°C in an absorption pas and put into polyethylene bag to determine drip loss percentage according to Owens and Sams (1998). For cooking loss analyses, samples were weighed before being put in vacuumed heat resistant plastic bags. They were then boiled at 85°C until the internal temperature reached 80°C, after which they were cooled to room temperature and weighed again (Allen *et al*., 1997).

Statistical analysis: All the data was statistically analyzed using ANOVA. The differences between the means of each group were separated by Duncan's Multiple Range Test. Statements of statistical significance are based on $p<0.05$. All statistical analyses were computed in accordance with the Steel and Torrie (1980) in accordance with the following model:

$$Y_{ij} = \mu + A_i + e_{ij}$$

where, Y_{ij} is the observed response, A_i is the effect of treatments and ε_{ij} is experimental error; $\varepsilon_{ij} \sim NID(0, d^2)$.

RESULTS AND DISCUSSION

Environmental conditions and growth performances: During the 42 days experimental period, the average daily lowest ambient temperatures were 26.70±0.82, 29.26±1.54 and 27.44±0.92°C while the highest were 34.50±1.35, 33.93±1.00 and 34.06±1.16°C during the starter, grower and finisher stages, respectively. On average, the lowest and highest temperatures during the trial were 27.21±1.16 and 34.12±1.15°C, respectively. The corresponding average relative humidity readings were 84.15±5.99, 79.93±9.11 and 70.83±5.21%. Thus, the average relative humidity during the experiment was 77.04±8.81%.

The effects of adding vitamins and organic acids into the drinking water on the production parameters of broiler during 1-42 days of age are shown in Table 2. The high relative humidity and the big gap between the day and the night temperatures of this trial indicated the level of environmental stress that the birds were subjected to Sosnowka-Czajka *et al*. (2005) reported that an ambient temperature range of 18-21°C generally supports optimal growth of animals. In the present study, the unfavorable environmental conditions negatively affected the birds' growth performance. As reported by Daghir (2009), the physiologic and behavioral responses of broilers are detrimentally affected by hot environmental conditions. They found out that for every 1°C increase in ambient temperature above 30°C, there was a corresponding decrease in feed intake of 2.43 g per bird.

Vitamin C is known to increase the expenditure of corticosteroids released during stress (Pardue and

Table 2: Effects of adding vitamins and organic acids in drinking water on performances of broiler during 1-42 days of age

Items	Control	Vitamin C	Vitamin C+E	Vitamin combination	Vitamin combination +organic acids	p-value
Body weight (g)	1,601.74±47.99^{C}	1,646.53±59.81^{BC}	1,718.30±71.22^{AB}	1,729.90±37.48^{A}	1,758.45±89.97^{A}	0.0019
Weight gain (g)	1,560.63±48.00^{C}	1,605.41±59.78^{BC}	1,677.18±71.22^{AB}	1,688.77±37.48^{A}	1,717.33±89.95^{A}	0.0014
ADG (g)*	37.16±1.14^{C}	38.22±1.42^{BC}	39.93±1.69^{AB}	40.21±0.89^{A}	40.89±21.4^{A}	0.0014
Feed intake (g)	3,189±58±180.35	3,083±264.49	3,290.13±119.07	3,270.68±225.94	3,318.44±163.62	0.2646
ADFI (g)**	75.94±4.29	73.42±6.30	78.34±2.83	77.87±5.38	79.01±3.90	0.2650
FCR	2.04±0.14	1.92±0.10	1.96±0.11	1.94±0.12	1.94±0.14	0.4398
Mortality	3.33±3.93	2.67±2.73	2.67±3.01	2.00±2.53	2.33±1.51	0.9464

*ADG is average daily gain. **ADFI is average daily feed intake. Data is Mean±SD. $^{A, B, C}$Means with different superscripts in the same row are highly significant (p<0.01)

Table 3: Effects of adding vitamins and organic acids on pH of the drinking water and on water intake of broilers during 1-42 days of age

Items	Control	Vitamin C	Vitamin C+E	Vitamin combination	Vitamin combination +organic acids	p-value
Water intake (kg/chick)	7.41±0.79	7.07±0.85	7.19±0.32	6.82±0.36	6.84±0.51	0.4413
Water:Feed	2.32±0.21^{a}	2.29±0.20^{a}	2.19±0.03^{ab}	2.09±0.09^{b}	2.06±0.12^{b}	0.0171
pH in drinking water	6.43±0.01^{A}	6.10±0.02^{C}	5.74±0.03^{D}	6.18±0.02^{B}	3.42±0.01^{E}	<0.0001

Data is Mean±SD, $^{A, B, C, D}$, ^{E}Means with different superscripts in the same row are highly significant ($p<0.01$), $^{a, b}$Means with different superscripts in the same row are significantly different ($p<0.05$)

Thaxton, 1984) and plays an important role in alleviating stress. This study revealed that adding vitamin C 40 mg L^{-1} in the drinking water slightly improved the body weight. The results obtained are similar to those reported by Jaffar and Blaha (1996) who observed that supplemental vitamin C at 20 mg/bird/day in the drinking water during acute heat stress (29-43°C and 40-85% relative humidity) improves the survival rate. It appears that the beneficial effects of vitamin C supplementation are more evident under high ambient temperatures. Blaha and Kroesna (1997) also observed an improvement in the FCR of broilers as a result of vitamin C supplementation during heat stress. In contrast, when the average environmental temperature was 26°C. Puron *et al.* (1994) found that vitamin C has no effect on performance and survivability. This was in agreement with the findings of McKee and Harrison (1995).

The treatment given the combination of vitamin C 40 mg L^{-1} and vitamin E 85 mg L^{-1} water showed a significantly increased body weight ($p<0.01$). The improved performance could possibly be ascribed to the combined alleviating effects of vitamin C and vitamin E in neutralizing the negative impact of heat stress. Vitamin E is necessary for cellular processes particularly in cell respiration and nucleic acid metabolism. Capable of minimizing oxidation within the tissues, vitamin E is considered to be the major chain-breaking antioxidant in lipid membranes inasmuch as it acts as a cell membrane protector by increasing lipid membrane orderliness (Halliwell and Gutteridge, 1989). In the present study, combining multivitamins with an amalgamation of organic acids and adding them to the drinking water resulted in significantly improved body weight and survival rate, as compared to control group.

When combined, vitamins work together or act synergistically. As an example, vitamin C and vitamin E serve as antioxidants in the biological systems and break the chain of lipid peroxidation in cell membranes (Packer *et al.*, 1979). Likewise, vitamins B complex play a key role in cell metabolism and is therefore essential for energy production in the body. The resulting added energy can serve as Co-enzyme during starvation or heat stress. Vitamin E, on one hand, plays a key role in enhancing immunity and productivity and is found effective if added at 16-65 IU kg^{-1} diet or 250 mg kg^{-1} diet. Vitamin A, on the other hand, is essential for several essential processes one of which is vision improvement. Also, it plays the role of an intracellular antioxidant and is usually added in the diet at around 7,714-10,000 IU kg^{-1}.

The effects of adding vitamins and organic acids on the pH of the drinking water and water intake of broilers during 1-42 days of age are presented in Table 3. Adding a combination of organic acids sharply decreased the pH in drinking water ($p<0.01$). However, in comparison with the control group, the supplementation of vitamins or organic acids showed a significantly decrease the volume of the drinking water consumed ($p<0.05$). This may have been caused by intestinal biostatics on acid-base balance (Fuller and Perdigon, 2003). The pH of the drinking water used in this study was within the accep range of 3-8 as reported by Kare and Roger (1976). However, there was a significant decrease in the water:feed consumption ratio in treatments given the vitamin combination as vitamin combination and organic acid and such decrease may due to a slight increase in feed intake.

Organic acids have the effect of suppressing the concentration of coliform populations in the gastrointestinal tract (Ravindran and Kornegay, 1993).

Among organic acids, mixed acidifiers have shown much improved positive effects on growth performance than single acid (Walsh *et al.*, 2007) Organic acids manifest their mode of action by dissociating inside the more alkaline cell interior, thus causing acidification of the cytoplasm and inhibition of cell metabolism of pathogenic microorganism (Lueck, 1980). Disease outbreaks are thus minimized and the growth performance of animals is enhanced (Knarreborg *et al.*, 2002). It is likewise believed that organic acids increase the population of lactic acid bacteria which produce lactic and acetic acids in the large intestinal tract and which in turn are used as an energy source of intestinal epithelial cell growth that improves nutrient absorption (Lampromsuk *et al.*, 2012). The foregoing could have transpired during the biological processes of the broilers and thus explain the positive effect of organic acids on the overall improvement in production performance.

Carcass yield and meat quality: The birds whose drinking water was supplemented with a combination of vitamins and organic acids showed increased body weight. However these treatments did not demonstrate any influence on the amount and percent of abdominal fats.

Table 4: Effects of adding vitamins and organic acids in drinking water on carcass quality of broiler at 42 days of age

Items	Control	Vitamin C	Vitamin C+E	Vitamin combination	Vitamin combination +organic acids	p-value
Carcass yield (%)	81.00±0.81^{A}	82.02±1.34^{A}	81.46±1.14^{A}	81.32±1.35^{A}	79.55±0.66^{B}	0.0089
Thigh (%)	13.09±0.36	13.02±0.14	12.99±0.42	12.66±0.56	12.62±0.60	0.2467
Drumstick (%)	10.53±0.37	10.50±0.45	10.77±0.18	10.69±0.31	10.22±0.38	0.0993
Inner breast (%)	3.78±0.30	3.74±0.22	3.68±0.25	3.75±0.40	3.42±0.17	0.2170
Outer breast (%)	13.34±0.72	13.49±1.05	13.12±0.94	13.32±1.64	12.77±0.80	0.8064
Upper wing (%)	4.01±0.27	3.90±0.04	4.01±0.10	3.89±0.12	3.88±0.13	0.3620
Lower wing (%)	4.04±0.12	3.69±0.80	4.10±0.16	4.19±0.12	3.98±0.04	0.2237
Visceralorgan (%)	12.93±0.75	12.75±0.89	12.75±0.64	12.59±0.90	13.98±1.11	0.0688
Heart (%)	0.28±0.04	0.27±0.01	0.28±0.03	0.28±0.02	0.28±0.02	0.9832
Liver (%)	2.34±0.28	2.37±0.19	2.22±0.13	2.16±0.08	2.23±0.10	0.2164
Gizzard (%)	1.64±0.16	1.61±0.14	1.53±0.14	1.64±0.09	1.61±0.17	0.6848
Bursa (%)	0.12±0.05	0.12±0.04	0.14±0.04	0.13±0.03	0.12±0.02	0.9017

Data is Mean±SD, ^{A,B}Means with different superscripts in the same row are significantly different (p<0.01)

Table 5: Effects of adding vitamins and organic acids in the drinking water on meat quality of broiler at 42 days of age

Items	Control	Vitamin C	Vitamin C+E	Vitamin combination	Vitamin combination +organic acids	p-value
Drip loss (%)	6.72±1.72^{a}	5.29±0.61^{ab}	4.86±1.12^{b}	5.11±0.90^{b}	5.17±0.72^{b}	0.0495
Cooking loss (%)	16.58±1.84	15.03±1.53	15.42±2.20	16.17±2.08	14.98±2.09	0.0965
Color						
L*	52.59±2.05	51.47±1.60	51.57±1.48	52.41±2.94	52.64±2.49	0.0835
a*	9.07±1.10	8.66±1.13	9.27±0.93	8.63±1.47	9.24±1.38	0.6340
b*	21.60±1.55	20.55±1.93	20.99±1.60	20.97±2.48	21.25±1.63	0.5709
pH at 45 min	6.20±0.26	6.43±0.17	6.34±0.27	6.37±0.26	6.39±0.17	0.1286
pH at 24 h	5.85±0.16	5.86±0.10	5.79±0.16	5.82±0.09	5.84±0.06	0.5914

Data is Mean±SD, ^{a,b}Means with different superscripts in the same row are significantly different (p<0.05)

The effects of adding vitamins and organic acids in the drinking water on carcass quality are shown in Table 4.

This study affirmed the findings of Howlider and Rose (1989) that high ambient temperatures suppress broiler carcass weight. This may be due to a decrease in the digestibility of amino acids which can be caused by high environmental temperature, as reported by Wallis and Balnave (1984). Similarly, Zuprizal *et al*. (1993) have likewise shown that true digestibility of protein and amino acids of two different protein sources (rapeseed and soybean meals) decreased as the environmental temperature increased from 21-32°C.

Table 5 shows the effects of enriching the drinking water with vitamins and organic acids on meat quality of broiler at 42 days of age. Adding vitamin C at 40 mg and vitamin E at 85 mg L^{-1} water, or vitamins combination 1 g L^{-1} water, or vitamins mixture 1 g L^{-1} water plus organic acids combination 1 mL L^{-1} water, significantly reduced the drip loss percentage of broiler meat when compared to the control group. Similarly, the pH of the carcass meat at 45 min of birds given vitamin C supplementation was not depressed. Likewise, the cooking loss percentage pH at 24 h and the color of the broiler meat were not influenced by vitamins or organic acids supplementation in the drinking water.

In order to reduce heat stress and enhance the immune system, unsaturated fatty acids are usually being added in the diet of chickens raised under tropical environment. This practice, however, induces more oxidative stress and thus requires high dietary antioxidants. In this study, it is evident that adding vitamin E at 85 mg L^{-1} sharply decreased drip loss. This result is in agreement with the report of Lahucky *et al*. (2000) which showed evident reductions in drip loss when high levels of vitamin E were added to the diet. Even in pigs, it was found that supplementing a higher level of vitamin E (500 mg kg^{-1} diet) administered for 46 days could reduce drip loss significantly (Cheah *et al*., 1995). One explanation as to how vitamin E could cause a reduction in lipid oxidation is that vitamin E enables the membrane phospholipids to influence the oxidative state of the muscles and their water-binding capacity. The finding of Van Laack and Spencer (1999) supports the results of this study vis-a-vis drip loss. This study's results, therefore, suggest that providing broiler chickens with a combination of vitamins and organic acids could be a good management strategy to counteract the negative impacts of heat stress on the overall productivity performance and carcass meat quality of broilers.

CONCLUSION

It can be concluded that vitamin and organic acid improved the performance under tropical condition. A combination of 40 mg of vitamin C + 85 mg of Vitamin E, vitamin combination 1 g and vitamin combination

1 g+organic acid 1 mL L^{-1} water may also be useful for body weight, weight gain, average daily gain and reduced drip loss value.

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