Livestock Science 135 (2011) 103–109

Contents lists available at ScienceDirect

Livestock Science

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

Effect of dietary betaine supplementation on growth, carcass and immunity of New Zealand White rabbits under high ambient temperature

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ARTICLE INFO

Article history:
Received 11 March 2010
Received in revised form 18 June 2010
Accepted 21 June 2010

Keywords:
Rabbit
Betaine
Heat stress
Growth
Carcass
Immunity

ABSTRACT

The objective of this study was to determine the effects of dietary betaine supplementation on growth performance, carcass characteristics, rectal temperature, respiration rate and immune response of growing rabbits under high ambient temperature. A total of 120 weaned New Zealand White male rabbits, 6 weeks old, were randomly divided into five experimental treatments (24 each). Animals were fed *ad libitum* the basal diet supplemented with 0 (control), 250, 500, 750 and 1000 mg betaine/kg diet from 6 to 12 weeks of age. Animals were provided with water freely. The average daily temperature and relative humidity inside the rabbitry were 30.3 ± 0.9 °C and 76.2 ± 2.5%, respectively. Under heat stress conditions, diet significantly increased the body weight and hot carcass weight and significantly reduced the feed conversion. Dietary 1000 and 750 mg betaine/kg increased ($P<0.05$) final body weights (2529.1 and 2418.5 g, respectively) compared with the control (2110.3 g). Betaine supplementation ameliorated some of the adverse effects of heat stress on immune responsiveness, rectal temperature and respiration rate. Dietary 250, 500, 750 and 1000 mg betaine/kg led to a decrease in rectal temperature (40.03, 39.85, 39.63 and 39.53 °C, respectively) compared with the control (40.20 °C). The inclusion of 1000 mg betaine/kg in the growing rabbits' diets nearly doubled the humoral and immune responses compared to the controls ($P<0.05$) and significantly reduced rectal temperature and respiration rate. Serum T3, T4, total protein, globulin and total lipids were significantly increased while serum glucose concentration was significantly decreased due to dietary betaine. In conclusion, supplemental dietary betaine enhanced growth performance and humoral and cell-mediated immunity as well as reduced rectal temperature and respiration rate in growing rabbits subjected to heat stress. From an economic point of view, high levels of betaine are not recommended because betaine is reasonably effective at lower, less expensive, doses.

1. Introduction

Betaine, or glycine betaine, is a naturally occurring compound, which is increasingly being used, in animal nutrition. Betaine has methyl donor and osmoprotective properties, which are essential in the nervous, immune, renal and cardiovascular systems (Kidd et al., 1997). Betaine supplementation significantly improved body weight gain and feed conversion in chickens (Zhan et al., 2006), ducks (Wang et al., 2004), geese (Su et al., 2009) and pigs (Campbell et al., 1995). Klasing et al. (2002) showed that betaine increased villi height in the duodenum and presumably absorptive area. Additionally, a positive effect of dietary betaine on carcass characteristics and fat distribution in ducks and chickens (Wang et al., 2004; Huang et al., 2006), respectively, and in pigs (Fernández-Fígares et al., 2008) has been indicated. Moreover, betaine is involved in enhancing immune response (Zhang et al., 1996; Klasing et al., 2002). Zhang et al. (1996) postulated that betaine is involved in regulating cytokines

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doi:10.1016/j.livsci.2010.06.132

production by liver macrophages (Kupffer cells) by inhibiting the prostaglandin synthesis in rats.

In hot periods, rabbits have difficulty eliminating body heat because of their non-functional sweat glands (Marai et al., 2002). Different physical and physiological methods have been used to alleviate the heat load in heat stressed animals. The physical methods used include sheltering, air conditioning, zone air cooling, drinking cool water, using wet or iced sacks in the cages, spray or sprinkling the roofs and floor with tap water and shearing. However, in all cases rabbits must be kept dry, since wet coats are predisposing causes for pneumonia and respiratory troubles (Marai et al., 2002) which have led to the investigation of a number of dietary agents which might alleviate the adverse effects of temperature. It is well known that body temperature and respiration rate are increased following exposure to high (>30 °C) environmental temperatures (Marai et al., 2001, 2002). In this respect, due to its ability to reduce body temperature and consequently respiration rate, betaine might be supplemented to the growing rabbits' diet during hyperthermic stress in order to alleviate some of the adverse effects of heat stress.

Addition of betaine to feeds improves performance under stress conditions that affect cell osmolarity including coccidiosis infection (Klasing et al., 2002) and heat stress (Zulkifli et al., 2004; Farooq et al., 2005). Wang et al. (2004) suggested that dietary betaine supplementation seems to improve resistance to stress. Dietary betaine (0.3 g/kg) has been shown to decrease heat stress in poultry (Zulkifli et al., 2004). Since betaine can have a positive effect on carcass yield and quality in both poultry (Wang et al., 2004) and pigs (Huang et al., 2006) and, because of its effect on cell osmolarity, the addition of betaine to feed might help to overcome the negative effects of heat stress on performance and carcass quality (Kidd et al., 1997; Metzler-Zebeli et al., 2009). These positive effects of betaine may also be related to reduction of body temperature in broiler chickens when betaine was added to the feed under heat stress conditions (Zulkifli et al., 2004). There is a lack of information on the effect of dietary betaine on performance, carcass characteristics and immunity in rabbits under heat stress conditions. In Egypt, the climate is characterized by a long hot period (from May to October) and short mild one (from December to March). The objective of the present study is to determine the effects of dietary betaine supplementation on performance, carcass characteristics, rectal temperature, respiration rate, blood serum constituents and immune response of growing rabbits under high ambient temperature.

2. Materials and methods

The present experiment was carried out in Sakha Research Farm, Animal Production Research Institute, Ministry of Agriculture, Egypt, from July to September; one of the hot periods of the year 2009.

2.1. Animals, diets and housing

A total of 120 weaned New Zealand White male rabbits at 6 weeks of age weighing 739.7 ± 35.3 g were randomly divided into five experimental treatments ($n=24$ each). The basal diet composition (Table 1) was formulated to meet the recommended nutrient requirements of growing rabbits (NRC, 1977). Chemical analyses of the experimental rations were carried out according to AOAC (2000) for crude protein (CP, Method 968.06), ether extract (EE, Method 920.39), crude fiber (CF, Method 932.09) and ash (Method 967.05). Animals were fed the basal diet supplemented with 0 (control), 250, 500, 750 and 1000 mg betaine/kg diet from 6 to 12 weeks of age. Betaine was provided as Betafin®-BP (betaine anhydrous/pharmaceutical grade, Finnfeeds Finland Ltd.). Rabbits were individually housed in stainless steel cages (35 × 35 × 60 cm) provided with feeders and automatic nipple drinkers where diet and water were offered *ad libitum*. The building was open air with electric exhaust fans on the sides. During the experimental period, ambient temperatures and relative humidity were measured in the rabbitry twice a day at 06:00 h and 15:00 h. The maximum and minimum daily temperature and relative humidity inside the rabbitry ranged from 26 to 34 °C and from 73% to 79%, respectively. Means of ambient temperature, relative humidity and temperature humidity index (THI) inside the building were 30.3 ± 0.9 °C, 76.2 ± 2.5% and 29.1, respectively, which indicate severe heat stress. According to Marai et al. (2002) there is severe heat stress when THI is higher than 28.9. The THI was calculated according to Marai et al. (2001):

$$\mathrm{THI} = \mathrm{db}°\mathrm{C} - [(0.31 - 0.031\mathrm{RH}) \times (\mathrm{db}°\mathrm{C} - 14.4)]$$

where, db°C is dry bulb temperature in Celsius degrees, and RH is the relative humidity as a percentage. All the experimental animals were healthy and clinically free from internal and

Table 1
Composition and chemical analysis of the experimental diet.

Ingredient	Diet (%)
Berseem	30.05
Barley grain	23.00
Yellow corn	1.60
Wheat barn	21.50
Soybean meal (44% CP)	17.50
Molasses	3.00
Limestone	0.95
Di-calcium phosphate	1.60
Sodium chloride	0.30
Mineral-vitamin premix [a]	0.30
DL-Methionine	0.20
Total	100.00
Chemical analysis on dry matter basis	
Dry matter (DM)	85.81
Organic matter (OM)	91.42
Crude protein (CP)	17.27
Ash	5.85
Crude fiber (CF)	13.55
Ether extract (EE)	2.58
Nitrogen free extract (NFE)	57.08
Metabolizable energy (ME, kcal/kg) [b]	2258.32
Calcium	1.28
Phosphorus	0.79
Methionine	0.45
Lysine	0.87
Starch	17.07

[a] Mineral–vitamin premix provided the following per kilogram of diet: vitamin A, 150,000 UI; vitamin E, 100 mg; vitamin K3, 21 mg; vitamin B1, 10 mg; vitamin B2, 40 mg; vitamin B6, 15 mg; pantothenic acid, 100 mg; vitamin B12, 0.1 mg; niacin, 200 mg; folic acid, 10 mg; biotin, 0.5 mg; choline chloride, 5000 mg; Fe, 0.3 mg; Mn, 600 mg; Cu, 50 mg; Co, 2 mg; Se, 1 mg; and Zn, 450 mg.

[b] Calculated on the basis of the ingredient composition.