J. Dairy Sci. 101:1–11
https://doi.org/10.3168/jds.2017-14210

An evaluation of an immunomodulatory feed ingredient in heat-stressed lactating Holstein cows: Effects on hormonal, physiological, and production responses

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ABSTRACT

Holstein cows (n = 30) were balanced by days in milk, milk production, and parity (91 ± 5.9 d in milk, 36.2 ± 2.5 kg/d, and 3.1 ± 1.4, respectively) and fed OmniGen-AF (OG; Phibro Animal Health, Teaneck, NJ), an immune stimulant, at 0 g/cow per d for control (CON) or 56 g/cow per d for OG for 52 d on a commercial dairy. At 52 d of the study cows were randomly selected (n = 12) from both groups (6 OG and 6 CON) and housed in environmentally controlled rooms at the Agricultural Research Complex for 21 d at the University of Arizona. Cows were subjected to 7 d of thermoneutral (TN) conditions, 10 d of heat stress (HS), and 4 d of recovery (REC) under TN conditions. Feed intake, milk production, and milk composition were measured daily. Rectal temperatures (RT) and respiration rates (RR) were recorded 3 times per day (600, 1400, and 1800 h). Blood samples were taken on d 7 (TN), 8 (HS), 10 (HS), 17 (HS), and 18 (TN) during the Agricultural Research Complex segment. Cows in HS had higher RR and RT and water intake and lower dry matter intake and milk yield than these measures in TN. There was a treatment × environment interaction with cows fed OG having lower RR and RT and higher dry matter intake during peak thermal loads than CON. However, milk yield did not differ between groups. Cows fed OG had lower milk fat percent than CON (3.7 vs 4.3%) during HS. The SCC content of milk did not differ between treatment groups but rose in both groups during the REC phase following HS. Plasma insulin and plasma glucose levels were not different between groups. However, plasma insulin in both groups was lower during acute HS, then rose across the HS period, and was highest during the REC phase. Plasma cortisol levels were highest in all cows on the first day of HS (d 8) but were lower in cows fed OG compared with CON. However, plasma ACTH concentrations were elevated in OG-fed animals at all times samples were collected. Plasma ACTH was also elevated in cows fed both OG and CON during HS. Feeding OG reduced plasma cortisol during acute but not chronic HS and increased basal plasma ACTH, suggesting that OG treatment may alter the hypothalamic pituitary adrenal axis.
Key words: cortisol, heat stress, immune stimulant

INTRODUCTION

A report by Kadzere et al. (2002) estimated that 48% or 4.2 million dairy cows in the United States are subjected to heat stress (**HS**) on an annual basis, negatively affecting milk yield, reproduction, and cow health. The economic impact of HS on the US dairy industry is estimated at $879 million by St. Pierre et al. (2003). Dairy cows begin to physiologically adjust to the detrimental effects of HS when the ambient temperature exceeds 32.2°C or the temperature-humidity index (**THI**) reaches 68 (Kadzere et al., 2002; Ortiz et al., 2013; Allen et al., 2015). The physiological responses of dairy cows to HS include increased body temperature and elevated respiration rates (**RR**; Igono et al., 1992). These physiological adaptive responses are followed by decreased feed intake, milk yield, milk components, and reproductive efficiency (Johnson and Vanjonack, 1976; Jordan, 2003). In addition to the negative effect on production, immune function and cow health are also negatively affected by HS associated with elevated cortisol associated with exposure to heat (Christison and Johnson, 1972; Sordillo, 2013).

The feed additive Omnigen-AF (**OG**; Phibro Animal Health, Teaneck, NJ) is a nutritional supplement for ruminants that has been shown to bolster immune function in replacement dairy heifers (Ryman et al., 2013), lactating dairy cows (Wang et al., 2009; Brandão

Received November 28, 2017.
Accepted April 21, 2018.
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et al., 2016), and sheep (Wang et al., 2007). Multiparous dairy cows fed OG from dry-off through 60 d into lactation (Fabris et al., 2017) and exposed to HS were observed to have higher milk responses than the control (**CON**) cows. Leiva et al. (2017) reported that feeding OG to lactating dairy cows reduced HS responses. These studies prompted a more detailed investigation to evaluate the physiological, immunological, and production effects of prefeeding OG to lactating dairy cows under controlled thermoneutral (**TN**) and HS conditions. We postulate that feeding OG to lactating dairy cows before and during HS will also improve HS physiological responses.

MATERIALS AND METHODS

All aspects of this protocol were approved by the Animal Care and Use Committee of the University of Arizona. Cattle were selected and sorted by DIM, production (previous lactation and current lactation), and parity. The 2 phases of the study were the on-dairy phase and the Agriculture Research Complex (**ARC**) phase. The on-dairy phase was conducted at a commercial dairy in Eloy, Arizona. The ARC phase took place at the University of Arizona, Tucson.

The on-dairy part of the study was needed to elicit an immune response before arrival at the ARC. Previous studies have established that a 52-d feeding period of OG supplementation is required to demonstrate differences in markers of immune function (e.g., IL-8 receptor, beta) between OG-fed cows and CON (Wang et al., 2004; Wu et al., 2017). The dairy used for the on-dairy phase (Caballero Dairy, Eloy, AZ) is a dry lot dairy with Saudi barns, which were cooled by Advanced Dairy Systems-Shade Tracker (ADS-ST, Chandler, AZ), an oscillating evaporative cooling system. Cows were milked 3 times daily in a rotary style parlor. A total of 504 cows were placed in 2 pens of 252 cows each. Both pens were in the same barn on opposite sides of the feed alley. All cows in each pen were fed CON or OG diets. All cows in the barn were fed and milked at the same time each day. The cooling systems (oscillating fans) for each side of the barn were operated by the same control system, which was set to begin cooling at a THI of 72. The CON and OG cows were offered fresh feed twice daily. The OG fed group received the same base TMR as the CON, and OG was mixed in at 56 g/cow per d. At the beginning of the on-farm phase, a total of 30 cows (15 CON and 15 OG) balanced by DIM, milk production, and parity were identified to obtain a pool of animals to be used in the ARC phase of the study. Animals in the on-farm phase were pen fed, and pen was confounded with treatment. Therefore, on-farm milk yields and metabolites were not tested.

Of the original 30 cows in the on-farm phase, 6 cows were selected from each group to provide 12 cows to be used for the ARC phase of the study. Cows in each group were balanced for milk yield, parity, and DIM. After arrival at the William Parker Agricultural Research Complex in Tucson, Arizona, the cows were weighed and fitted with halters to accommodate their tiestalls. The 12 cows were then randomly assigned by coin flip to 1 of 2 environmentally controlled rooms with 3 CON and 3 OG cows per room for a total of 6 cows per treatment. The stalls in each room were of identical size, and the room dimensions of both rooms were identical. Stalls faced north in one room and south in the second room. A single heating, cooling, and humidifying system was used to control the environment in both rooms. Cows were continuously monitored for the first 48 h following arrival to prevent injury during acclimation to the rooms and the tiestalls. During the night, cows were observed through remote access cameras.

The ARC phase of the trial lasted 21 d and was composed of 3 periods. There were 7 d of acclimation at TN to allow the cows to settle and adjust to their surroundings. After the acclimation period, the cows were subjected to 10 d of HS. Cows were then given a recovery period at TN for 4 d before returning to the commercial dairy (Figure 1).

Feeding and milking in the ARC phase occurred twice daily at 0500 and 1700 h. Cows were individually fed and milked in their own tiestalls. The CON cows were fed the base TMR (Table 1) plus ~25 g of molasses (as-fed) mixed into the top one-third of each meal, and the OG cows received the TMR + molasses + 28 g of OG mixed into the top third of each meal. Orts were removed daily at 1645 h and weighed. Water consumption was metered and recorded daily before the AM feeding. Milk bucket weights were taken, and a daily milk sample was taken from the AM milk. Samples

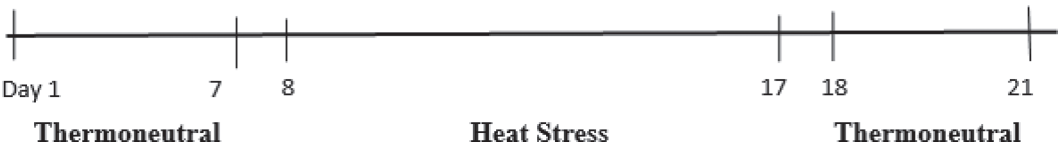

Figure 1. Thermal conditions in the controlled environment rooms during the 21-d Agriculture Research Complex phase of the study.