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Research Paper

Exposure to sunlight results in lower concentrate intake during the hot hours of day in a cafeteria feeding of chopped alfalfa hay and concentrate in Afshari lambs

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ABSTRACT

It is commonly believed that ruminants exposed to sunlight, and consequently heat stress (HS), consume more concentrate and lower forage, but there is limited evidence on this issue. The objective of this study was to determine the productivity and voluntary intake of concentrate and alfalfa hay in a cafeteria delivery method in the outdoor (OUT)- versus indoor (IN)-housed growing Afshari lambs during summer. Thirty intact male lambs (30.4 ± 4.6 kg) were randomly housed OUT and subjected to sunlight without any shade or kept IN under shade for a period of 42 days. The average temperature humidity index for IN and OUT environments were 69.8 and 70.7 (over ~72 for more than 12 h/day), respectively. Feed intake (concentrate and hay, separately), rectal temperature and respiration rate were measured two times a day at 0800 and 1530 h through the experiment. Although hay intake was not different between two groups since morning feeding until 1530 h, OUT lambs had lower concentrate intake (611 vs. 535 g for IN and OUT, respectively; $P < 0.02$) at the same time. Total concentrate consumption, however, tended to be greater for OUT compared to IN lambs (1 418 vs. 1 513 g/day for IN and OUT, respectively; $P < 0.06$), without any difference in hay intake. Accordingly, OUT treatment resulted in greater (~120 g/day; $P < 0.04$) total dry matter intake (concentrate + hay). The OUT lambs tended (~1.3 kg; $P < 0.07$) to outweigh IN lambs at the end of the experiment. Despite the fact that both groups had similar average daily gain (ADG) until the half of the experiment, IN lambs had lower ADG (369 vs. 431 g/day; $P < 0.01$) until the end and through the study. Feed efficiency was not affected by treatments. The morning rectal temperature was influenced by treatment whereby IN animals were warmer (~0.2 °C; $P < 0.01$), whereas the evening rectal temperature was greater in OUT lambs (~0.2 °C; $P < 0.04$) and had more evening respiration rate (~53 more breath per minute; $P < 0.01$). Among the blood metabolites, non-esterified fatty acid elevated for OUT lambs ($P < 0.01$), while glucose and insulin were not affected. Generally, under the conditions of the current experiment, exposure to sunlight did not result in increased concentrate intake during the hottest times of day and warrants more research in large ruminants to revise the old beliefs.

1. Introduction

There is no doubt that heat stress (HS), as a global problem, is threatening efficient animal production (West, 1999; Bernabucci et al., 2010). Because it has been predicted that climate changes continue (Thornton et al., 2007) and HS will become even more apparent in the future, recognizing strategies to alleviate the negative effects of current and future climate changes on the productive performance of animal more matters (Baumgard and Rhoads, 2013).

Nutritional approaches to minimize negative effects of HS are of interests among the others, based partly on the heat increment of feedstuffs (Bernabucci, 2012). The newest nutritional approaches during the last decade included feeding protected niacin (Zimbelman et al., 2010), Cr supplementation (Mirzaei et al., 2011), monensin supplementation (Baumgard et al., 2011), glucose precursors (Hossein Yazdi et al., 2015; Mahjoubi et al., 2016) and carbohydrate fermentability (Gonzalez-Rivas et al., 2016). It is believed that heat increment for fermentation is higher for fiber than concentrates (Webster et al., 1975) and heat production is more associated with metabolism of acetate than with propionate. Because of the reduced feed intake in HS, a common approach is increasing diet energy density, reducing forage, and increasing concentrate content of the ration. The argumentation is

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that less forage will increase intake, while more concentrates increase the energy density of the diet (Bernabucci, 2012); but feeding excessive grain should be carefully monitored as heat-stressed ruminants are susceptible to rumen acidosis (Kadzere et al., 2002). Bernabucci et al. (1999) with only four 10-mo-old Friesian heifers showed that heat-stressed animals lowered total feed intake only based on consumed hay while there was no preference for more concentrate intake. However, our unpublished observations (Mahjoubi et al., 2014,2016) showed that heat-stressed Afshari lambs in climate chambers sort against concentrates. Although the logic of decreasing feed intake in heat-stressed animals is partly an adaptive strategy to alleviate the heat production, the heat increment is not only associated with fiber content of diet but also to type of fiber fed (Bernabucci, 2012) or the total intake (West, 1999).

We hypothesized that growing Afshari lambs subjected to sunlight would consume more hay than concentrate compared to those lambs kept under shade. We also hypothesized that if they consume more hay they would have greater productive performance. Our study objectives were: to evaluate the voluntary hay and concentrate intake in a cafeteria offering whether under sunshine or under shade; to evaluate the productive performance; and to evaluate the blood metabolites.

2. Materials and methods

2.1. Animals and experimental design

Lambs were cared for according to the guidelines of the Iranian Council of Animal Care (1995). This experiment was carried out during July and August 2016. Thirty intact growing male Afshari lambs (30.4 ± 4.6 kg BW) were selected and housed in individual stalls (2 m × 1 m; with individual feeders and waters) 2 weeks before the start of the experiment in order to adapt to the diet and stalls, as we have previously described (Mahjoubi et al., 2015). Feed was delivered in a cafeteria feeding method (hay and concentrate in separate feeders) at 0800 and 1530 h. The concentrate primarily consisted of ground corn grain, ground barley grain, wheat bran and soybean meal. The ration was formulated to meet or exceed NRC (2007) recommendations using Small Ruminant Nutrition System (Tedeschi et al., 2010; version 1.9.4468). Diet ingredients and chemical composition of alfalfa hay and concentrate are shown in Table 1. This trial lasted 42 days where half of the lambs (n = 15) were housed outdoor (OUT) in individual stalls and subjected to sunlight during day time (~16 h light and 8 h dark) through the experiment and half of the lambs (n = 15) were kept indoor (IN) under the shade. The temperature and humidity index (THI) was calculated using the following equation:

THI = [0.8 × ambient temperature (°C)] + [(% relative humidity/100) × (ambient temperature − 14.4)] + 46.4 (Buffington et al., 1981). Mean THI during the day is presented in Fig. 1.

Table 1
Ingredients and chemical composition of diet (DM basis).

Item	
Alfalfa hay [a]	–
Ground barely grain (g/kg)	296.0
Ground corn grain (g/kg)	247.0
Wheat bran (g/kg)	118.0
Soybean Meal (g/kg)	303.0
Sodium Bicarbonate (g/kg)	17.0
Salt (g/kg)	6.0
Mineral-vitamin premix [b] (g/kg)	13.0
Chemical composition	
DM	89
Metabolizable energy [c] (Mcal/kg)	2.4
Crude protein (% DM)	20.9
Neutral detergent fiber (% DM)	21.1
Crude fat (% DM)	2.7

[a] Alfalfa hay contained 13.4% crud protein, 44% neutral detergent fiber, and 2.13 Mcal/kg metabolizable energy.
[b] Contained 700000 IU/kg Vitamin A, 600000 IU/kg Vitamin D, 1000 IU/kg Vitamin E, 1000 mg/kg monensin, 250 g/kg Ca, 200 g/kg Mg, 8 mg of Co, 800 mg of Cu, 40 mg of I, 3200 mg of Mn, 10 mg of Se, 3000 mg of Zn.
[c] Estimated using the Small Ruminant Nutrition System (Tedeschi et al., 2010; version 1.9.4468) individual dietary ingredients.

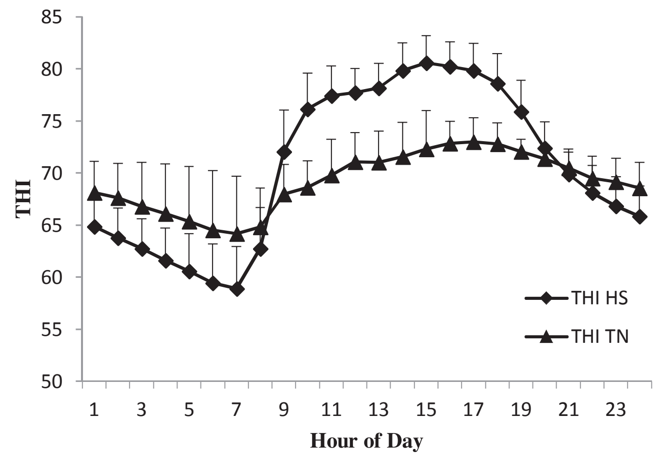

Fig. 1. Average (mean ± SD) diurnal patterns of temperature-humidity index (THI) during outdoor (OUT) or indoor (IN) keeping conditions.

2.2. Measurements

Consumed amount of alfalfa hay and concentrate was recorded twice a day at 0800 and 1530 h to evaluate the consumed hay and concentrate since the morning feeding until the warmest hour of day as well as total dry matter intake (DMI), respectively. Body temperature indices were obtained from all animals at 0730 and 1500 h daily, and included rectal temperature (RT; PIC Vedodigit II, Digital Thermometer, Pic Solution Co., Como, Italy; with ± 0.1 °C accuracy of measurement) and respiration rate (RR; recorded by counting the flank movements during 60 s). Body weight was recorded weekly before offering the feed in the morning and the difference was divided by 7 to compute ADG.

Two data loggers (MASTECH, model MS-6505, Taipei, Taiwan) continuously recorded the temperature and humidity data in 15 min intervals. The data loggers were suspended at a height of approximately 1 m above the floor (approximate lamb wither height) for the duration of the experiment.

2.3. Metabolite and hormone assays

Jugular vein blood (5 mL in vacutainer tubes containing 200 United States Pharmacopeia units of sodium heparin) was obtained prior to morning feeding on 20th and 40th day of study as previously described (Mahjoubi et al., 2014). Blood was centrifuged at 2000*g* for 15 min to harvest plasma, and then was stored at −20 °C for later analysis. Plasma glucose kits (GOD-PAR, Pars Azmun Laboratory, Tehran, Iran), K (Pars Azmun Laboratory, Tehran, Iran) and non-esterified fatty acid (NEFA) concentrations (NEFA-HR(2) assay kit, Wako Chemicals GmbH, Neuss, Germany) were determined enzymatically using commercially available kits. The plasma samples were analyzed by a BT 1500 automatic biochemistry analyzer (Biotechnica Instruments S.p.A, Rome, Italy) which simultaneously measures plasma samples for all the aforementioned diagnostic tests. Insulin concentrations were determined with an ELISA kit (Cat. No. 2425-300A, Monobind Inc, Lake Forest, CA, USA).