EFFECT OF ENVIRONMENTAL TEMPERATURE ON WATER EVAPORATION OF COWS

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Introduction

Heat stress in a hot climate reduces feed intake, milk yield and milk fat content of dairy cows. The studies on the effect of environmental temperature on lactation show that a fall in milk production under high temperatures closely associates with an increase in body temperature. On the other hand, body temperature depends on a balance between heat production and heat loss. Then we investigated the effect of heat stress on body temperature, respiration rate, heat production and evaporative heat loss of dairy cows.

Materials and Methods

Eight dry (4/trial x 2 trials) Holstein cows and eight lactating (4/trial x 2 trials) Holstein cows were housed in 4 open-circuit respiration chambers and exposed to 3 different temperature treatments of 18, 26 and 32 °C (lactating cows: 30 °C) with 60 % relative humidity for 2 weeks per treatment. All the cows were fed at a level corresponding to their nutrient requirements in the chamber. Body temperature (BT) and respiration rate (RR) of each cow were measured at 10:30 (lactating cows: 11:00), 15:00 and 20:00 h. for last 7 days of each treatment. Heat production (HP) and total water evaporation (TWE) of each cow were measured for last 4 days of each treatment. HP was calculated by using the Brouwer equation (Brouwer, 1965). TWE was determined by calculating the difference between the sum of water drunk voluntarily, water contained in feed and metabolic water (calculated by using the van Es equation: van Es, 1969) formed in the body and the sum of water losses through milk, feces, urine and saliva. Heat loss by water evaporation was calculated by multiplying the amount of TWE (g) by 582 cal/g (vaporizing energy).

Results and Discussion

The treatment effects on the BT of dry cows and lactating cows were significant. The RR of dry cows and lactating cows significantly increased with the rise in the temperature. The BT of lactating cows above 26 °C was higher than that of dry cows and the RR of lactating cows at any temperature was more than that of dry cows. It is considered that these results were due to the difference of the HP between dry cows and lactating cows. The HP of dry cows was almost the same value under the 3 different temperatures, but that of lactating cows significantly decreased with the increased temperature.

The TWE of dry cows and lactating cows significantly increased with the rise in the temperature. The ratio of the evaporative heat loss to the HP was about 30-35 % at 18 °C but it increased to about 50 % or more above 26 °C. This result shows that water evaporation plays a major role in heat loss of dairy cows above 26 °C. Five regression equation were derived from the data obtained in this experiment.

Dry cows :

$$Y = 0.299 \cdot X_1 - 2.488 \quad (r=0.839^{**}) \ldots\ldots (1)$$
$$Y = 0.100 \cdot X_2 + 1.532 \quad (r=0.880^{**}) \ldots\ldots (2)$$

Lactating cows :

$$Y = 0.399 \cdot X_1 \; 3.148 \quad (r=0.837^{**}) \ldots\ldots (3)$$
$$Y = 0.106 \cdot X_2 + 1.413 \quad (r=0.786^{**}) \ldots\ldots (4)$$

Pooled data of dry cows and lactating cows:

$$Y = 0.105 \cdot X_2 + 1.429 \quad (r=0.848^{**}) \ldots\ldots (5)$$

where Y, X_1 and X_2 are TWE ($g/kg^{0.75}$/hr.), BT (°C) and RR (resp./min.), respectively. The TWE of dry cows was calculated by using the equation (1) to be 3.49 $g/kg^{0.75}$/hr. at 20 °C and 6.48 $g/kg^{0.75}$/hr. at 30 °C. The TWE of lactating cows was calculated by using the equation (3) to be 4.83 $g/kg^{0.75}$/hr. at 20°C and 8.82 $g/kg^{0.75}$/hr. at 30°C. The TWE of dry cows calculated by using the equation (1) is essentially in agreement with that of Kibler and Brody (1962) at a similar temperature. The TWE of lactating cows at 20°C calculated by using the equation (3) is similar to that of Yeck and Stewart (1959) but the

TABLE 1. TREATMENT MEANS FOR BODY TEMPERATURE (BT), RESPIRATION RATE (RR), HEAT PRODUCTION (HP), TOTAL WATER EVAPORATION (TWE) AND THE RATIO OF EVAPORATIVE HEAT LOSS (EHL) TO HP OF COWS

Item	Treatment means			Treatment effects ($P < .01$)	l.s.d.[2]
	18 °C	26 °C	32(30) °C[1]		
	Dry cows (n=8)				
BT (°C)	38.39	38.51	39.31	**	0.48
RR (resp./min)	19.8	30.9	56.5	**	9.6
HP (kcal/kg$^{0.75}$/day)	124.0	127.2	122.7	NS[3]	
TWE (g/kg$^{0.75}$/day)	76.8	110.2	179.8	**	20.9
EHL/HP (%)	35.8	50.8	84.9	**	7.9
	Lactating cows (n=8)				
BT (°C)	38.40	39.09	40.05	**	0.53
RR (resp./min)	29.3	51.2	68.2	**	6.7
HP (kcal/kg$^{0.75}$/day)	205.6	190.6	175.7	**	11.2
TWE (g/kg$^{0.75}$/day)	98.6	168.0	215.3	**	44.9
EHL/HP (%)	27.8	51.2	71.4	**	12.0

[1] 32°C for dry cows, 30 °C for lactating cows.
[2] l.s.d.; least significant difference.
[3] NS; Not significant ($P > .05$), ** $P < 0.01$.

value at 30 °C is a little more than their value. These equations should be useful when water evaporation of dairy cows was calculated for the design of cow housing in a hot climate. The TWE of dry cows calculated by using the equation (2) was as much as that of lactating cows calculated by using the equation (4) when the RR of dry cows and lactating cows were the same value. Therefore the TWE of dairy cows would be calculated by using the equation (5). McLean and Calvert (1972) reported that water evaporation from the respiratory tract and the body skin both increased at high temperature (35 °C) but sweating increased most and respiratory water evaporation accounted for 38 % of total water evaporation. However, our result shows that a respiration rate is apparently useful as a parameter indicating the rise in total water evaporation of dairy cows.

(Key Words: Heat Production, Water Evaporation, Cows)

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