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EFFECTS OF WATER SPRAY ON BODY SURFACE TEMPERATURE, MILK PRODUCTION, HAEMATOLOGICAL AND BIOCHEMICAL METABOLITES OF EGYPTIAN BUFFALOES (*BUBALUS BUBALIS*) DURING THE HOT SUMMER MONTHS IN EGYPT

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ABSTRACT

Low milk yield and impairment of reproduction and production performances of dairy buffaloes is still a major problem in tropical areas as a result of high environmental temperature. The objective of this study was to determine the effect of water spray on milk production, haematological and biochemical parameters of Egyptian buffaloes (*Bubalus bubalis*) during the summer season. Twenty Egyptian buffaloes were divided into two groups of ten animals each on the basis of body weight and lactation stage. The first group was housed in a stable without water spray (control group), while the second group was housed in a stable where a system of water tubes was provided at 1.5 meters over the animals, ended with nozzles (2 meter apart from each other) to allow spraying water over the animal body surface for 15 minutes per hour from 14:00 to 9:00 hour daily for 4 months during the summer (cooled group). Our results revealed that the rectal, udder, and milk vein temperatures were significantly ($P < 0.001$) reduced as a result of water spray treatment. Daily milk yield in buffalo cows significantly ($P < 0.001$) increased as a result of the water spray. Milk fat, lactose, and total solids were significantly increased, while milk protein was not affected. Buffaloes' blood metabolites were also affected by water spray. The results of this study suggest that providing the Egyptian buffaloes with water spray for cooling their bodies reduced the adverse effect of heat stress during the period of highest temperature humidity index, and increased the milk yield.

Key words: water spray; heat stress; milk production; haematological metabolites; Egyptian buffaloes

INTRODUCTION

In Egypt, buffaloes serve as an economically important source of meat and milk. Buffaloes produce about 66 and 43 % of the national milk and meat production, respectively (FAO, 1996). Buffaloes are well suited to hot and humid climates and muddy terrain, but exposure to direct solar radiation or high air temperature when working in the sun during hot summer months in Egypt cause buffaloes to accumulate heat due to their dark skin and sparse coat or hair in addition to poor sweating ability. Exposure of buffaloes to the hot conditions resulted in impairment of reproduction and production performances. Buffaloes were raised successfully without wallowing as long as adequate shade is available (Marai *et al*., 2009). However, dramatic climate changes during the last few years raise attention to look for ways to reduce exposure of the animal to high environmental temperature, especially in desert new reclaimed lands. During the Egyptian summer in the climate of Eastern Desert, the increase in ambient temperature resulted in an increase in rectal temperature and respiratory

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rate from 37.9 to 39.7 °C and from 23.4 to 41.0 breaths/min, in lactating buffalo cows (Kamal *et al*., 1978). To manage heat load, dairy producers provide shade, fans, and spray cooling, which improves feed intake and milk yield under hot conditions (Chen *et al*., 2013). Environmental modifications have been performed in attempts to alleviate severe heat stress in dairy cattle, for example, water spray and fans (Armstrong *et al*., 1994), and evaporative cooling (Armstrong *et al*., 1988). When given access to both feed bunks with and without water cooling, cattle preferred feed bunks with sprinklers, and the magnitude of preference increased with ambient heat load (Chen *et al*., 2013). The objective of the current study was to investigate the effect of using sprinklers mounted over the feed bunk on surface body temperatures, milk yield and composition, and blood metabolic parameters of Egyptian buffaloes. It was hypothesized that water spray application would increase the ability of heat dissipation and subsequently optimize metabolic rate and process of milk formation.

MATERIAL AND METHODS

The present study was carried out at the experimental dairy farm at the Department of Animal Production, Faculty of Agriculture, Benha University, Egypt. All experimental procedures were reviewed and approved by the Animal Ethics Committee at the Benha University. A total number of 20 buffalo cows between the first and the third parity, with age ranging from 25 to 65 months were subjected to the study. Average body weight ranged from 449 to 728 kg. Animals were kept in tie stalls in semi-open sheds with a tail-to-tail arrangement. After grazing time, animals were kept under shed offering diet up to the sundown after which all animals were moved to the stable. During summer months animals were divided into two different groups on the basis of body weight and lactation stage. In the first group, animals were allowed to graze from 9:00 to 14:00 hour then kept under shed from 14:00 to 18:00 hour the time of sundown then kept in the stable overnight (control

Figure 1. Experimental animals for stable and outdoor

group). The animals of the second group were allowed to graze during the period from 9:00 to 14:00 then kept in a stable provided with system of water tubes at 1.5 meter over the animals ended with nozzles (2 meter apart from each other) to allow spraying of water automatically over the animal body surface for 15 minutes per hour (from 14:00 until 9:00 next day) to increase dissipation of body heat by evaporation (cooled group).

Feeding and Management

The study was conducted during the summer and early fall from the middle of May to the end of December. Animals were fed a concentrate mixture, wheat, and rice straw according to their maintenance and production requirements with an allowance of 5 h grazing per day (from 09:00 to 14:00 h). All animals were offered wheat (15 kg/head), and rice hay (5 kg/head) once per day in addition to concentrated feed mixture containing protein (14 %), crude fiber (22 %), moisture (12 %), crude ash (12 %) and total digestible substances (55 %). All animals were healthy and clinically free from diseases. Buffaloes were hand--milked twice per day (at 7:00 and 14:00 h), and milk yield was recorded individually for each milking time and calculated as the total daily milk yield.

The ambient temperature and relative humidity were recorded daily every 30 min for the entire experimental period in both stables and outdoors using data loggers. The temperature humidity index (THI) was calculated according to the following equation developed by Gelade *et al*. (2007): THI = 0.72 (DBT+WBT) + 40.6, where DBT is the dry bulb temperature, and WBT is weight bulb temperature. The average monthly air temperature, relative humidity, and THI were recorded throughout the experimental period from June to September (Table 1).

Physiological Measures

1- Internal body temperature

The surface temperatures at three different body regions (rectum, udder, milk vein) were measured bi-weekly three times per day (6:00, 14:00 and 19:00 h) using an infrared thermometer (AR330, Techman®, China). The measurement range of the infrared thermometer was -50 to 330 °C with accuracy of ± 1 °C. The infrared thermometer was kept at the pen environment temperature for at least 10 min before use. The infrared thermometer was kept at 10 cm from each body region for 20 buffalo cows.

2- Milk yield and composition

Each individual buffalo was milked two times per day (at 7:00 and 14:00 h). Daily milk yield was recorded daily for each individual cow. Milk samples were collected from each milking time two times per month all over the whole experimental period and sent for laboratory analysis. Total solids, protein, fat, ash, and lactose percentages were determined for each milk sample using AOAC procedures (1984).

3- Blood sampling and analyses

Two blood samples (10 mL) were collected from each buffalo cow into tubes containing heparin as an anticoagulant (one for whole blood and another for plasma separation) through the jugular vein puncture. Blood samples were collected after

Table 1. Average monthly air temperature (T), relative humidity (RH) and temperature humidity index (THI) at the site of experimental during the experimental period from June to September

Time	0:00 – 8:00 hour			8:00 – 12:00 hour			12:00 – 20:00 hour			20:00 – 24:00 hour		
Month	T, °C	RH, %	THI, F	T, °C	RH, %	THI	T, °C	RH, %	THI, F	T, °C	RH, %	THI, F
June	30.43	48.36	78.45	34.36	31.16	74.69	26.84	59.05	80.91	24.75	81.18	73.63
July	29.44	66.07	78.80	34.33	44.55	77.68	28.03	75.28	82.96	25.75	88.97	75.53
August	30.56	60.40	79.93	34.39	46.94	77.25	27.56	77.92	83.39	25.43	87.40	74.99
September	28.78	54.23	76.86	31.04	42.81	73.35	24.93	73.65	78.37	22.61	81.05	70.76

The ambient temperature and relative humidity were recorded daily every 30 min for the entire experimental period in both stable and outdoor by using data loggers. The obtained values indicate the following: < 72 = absence of heat stress, 72 to < 74 = moderate heat stress, 74 to < 78 = severe heat stress and 78 and more = very severe heat stress.

morning milking at 7 am and monthly until the end of the experimental period. Plasma was harvested within 1 h by centrifuging the sample at 3000 g for 15 minutes. The samples were frozen at -20 °C until subsequent analysis. Total plasma protein, albumin, total lipids, total cholesterol, calcium and phosphorus, and alkaline phosphatase were analyzed using commercial kits (Biodiagnostic, Egypt). Red and white blood cells and blood hemoglobin concentration were measured within one to two hours of collection using automated analyzer.

Statistical analyses

The data were statistically analyzed by using SAS (2004) with generalized linear model including the effects of treatment. Analysis of variance and Duncan's multiple range test (Duncan, 1955). Significant results were obtained from the least squares means and F scores ($P < 0.001$).

RESULTS

Effect of water spray on body surface temperatures

Our results revealed that the rectal, udder, and milk vein temperatures significantly ($P < 0.001$, Table 2) decreased as a results of water spray treatment during the hot months in Egypt. An interaction between treatment and time were observed for udder temperature ($P = 0.002$), and for milk vein temperature ($P = 0.014$). Lowest udder and milk vein temperature was observed in treated buffalo cows at 19:00 h, but there was no interaction between treatment and time observed for rectal temperature.

Effect of water spray on milk yield and composition of buffalo cows

Daily milk yield in buffalo cows significantly ($P < 0.001$) increased due to water spray treatment (Table 2). Average daily milk yield was 5.23 kg in treated groups versus 3.41 kg in control groups. Milk ash content increased from 0.81 % in untreated buffalo cows to 1.06 % in treated ones (Table 2). However, no effect of treatment was observed for milk protein. Treating lactating buffaloes with cooling system significantly ($P < 0.001$, Table 2) increased the average of milk fat and total solids percentages.

Effect of water spray on blood metabolites of buffalo cows

Cooling of buffalo cows during hot summer months had highly significant effect ($P < 0.001$, Table 2) on haemoglobin level, red and white blood cells. The treated buffaloes had significant increase

Table 2. Effect of water spray on different measured traits (Mean ± SE)

Variables	Control group	Water spray	*P*-value
Daily milk yield, kg	3.41 ± 0.43	5.23 ± 0.14	
Milk ash, %	0.81 ± 0.05	1.06 ± 0.04	< 0.05
Milk fat, %	8.84 ± 0.26	10.37 ± 0.21	< 0.001
Milk lactose, %	5.32 ± 0.04	5.30 ± 0.03	< 0.001
Milk protein, %	3.66 ± 0.16	4.72 ± 0.12	NS
Milk total solids, %	17.66 ± 0.28	20.40 ± 0.32	< 0.001
Blood Hemoglobin, g.dL^{-1}	11.57 ± 1.09	16.11 ± 1.09	< 0.001
Red blood cells, x 10^6	2.4757 ± 39.30	5.3577 ± 39.30	NS
White blood cells, x 10^3	3169.44 ± 727.59	4968.52 ± 727.59	NS
Plasma total protein, g.dL^{-1}	7.05 ± 1.02	10.04 ± 1.02	NS
Plasma albumin, g.dL^{-1}	4.61 ± 0.65	7.64 ± 0.65	NS
Plasma globulin, g.dL^{-1}	2.44 ± 0.63	2.55 ± 0.63	NS
Plasma total lipids, mg.dL^{-1}	3.23 ± 0.42	4.79 ± 0.61	NS
Plasma cholesterol, mg.dL^{-1}	56.13 ± 13.15	113.11 ± 13.61	NS
Plasma calcium, mg.dL^{-1}	10.30 ± 1.23	12.15 ± 1.28	NS
Plasma phosphorus, mg.dL^{-1}	5.20 ± 0.47	6.11 ± 0.47	NS
Alkaline phosphates, mg.dL^{-1}	341.91 ± 59.81	297.96 ± 51.93	NS

in plasma total proteins, albumin, total lipids, cholesterol, calcium, and phosphorus (P < 0.05, Table 2). Although, there were no significant effects detected in the plasma level of globulin and albumin (P > 0.05, Table 2).

Effect of water spray on body surface temperature of buffalo cows

Table 3 shows the effect of water spray on body surface temperatures of Egyptian buffaloes at different times of day. The water spray group showed the body temperature was lower (33.70, 34.16 and 32.89 °C, for rectal, udder and milk vein, respectively) than the control group. The differences between means of body surface temperature due to treatment groups were significant (P < 0.05).

DISCUSSION

Results revealed that the highest THI was observed during the period from 12:00 to 20:00 h; ranging from 78.37 to 80.91. The THI has been used for several years in the USA as a guide for the use of precautionary measures, which must include considerations of handling and deterioration. Recommendations based on forecasted THI values, were categorized as follows: THI < 70 = Normal: no heat stress precautions are needed; THI 70 – 80 = Alert: to be prepared to take extra precautions and do not leave a vehicle loaded with animals standing in the sun; THI 79 – 83 = Danger: additional precautions should be taken to protect animals. Use of sprinklers and fans in loading areas is advisable. Therefore, the goal of the current study is to use sprinklers during the period of high heat stress to cool the body of buffaloes. The obtained results agree with Vaidya *et al*. (2011), who found that the average maximum temperature was observed at 14:00 h and THI of 85 during the summer season in Murrah buffaloes and Karan Fries cattle. In our study, the average daily milk was increased as a result of increasing the rate of heat dissipation by applying spray of water above the body surface of the animals. Average daily milk yield reached an average approximately equal to that obtained during winter in Egyptian buffaloes

Table 3. Effect of water spray on body surface temperatures of Egyptian buffaloes during different times of the day

Variables	Rectal temperature	Udder temperature	Milk vein temperature
Treatment			
Control	34.20 ± 0.39	34.7775 0.5086	33.4371 0.5908
Water spray	33.70 ± 0.44	34.1623 0.5837	32.8997 0.6761
P-value	0.0021	0.0009	0.0154
Day period			
Period 1 (6:00 hour)	34.53 0.4220	35.1413 0.5488	33.9641 0.6369
Period 2 (14:00 hour)	34.11 0.4230	34.7888 0.5500	33.6468 0.6383
Period 3 (19:00 hour)	33.21 0.4233	33.4796 0.5502	31.8944 0.6386
P-value	< .0001	< .0001	< .0001
Water spray × 6:00 hour		35.06 ± 0.59	33.90 ± 0.68
Water spray × 14:00 hour		34.13 ± 0.59	33.02 ± 0.69
Water spray × 19:00 hour		33.29 ± 0.59	31.77 ± 0.69
Control × 6:00 hour		35.22 ± 0.53	34.02 ± 0.62
Control × 14:00 hour		35.44 ± 0.53	34.27 ± 0.62
Control × 19:00 hour		33.66 ± 0.53	32.00 ± 0.62
Treatment × Time, P-value	0.271	0.002	0.014

Temperatures were measured using an infrared thermometer (AR330, Techman, China) at 16:00 to 17:00 h once every two days during the first 15 days after regrouping. The measurement range of the infrared thermometer was -50 to 330 °C and the accuracy was ± 1 % or ± 1 °C. The infrared thermometer was placed at least 10 min in the pen environment before use.

(4.5 kg; Farouk, 2012). Ambient temperature as well as environmental humidity and nutritional efficiency are considered the most imported non-genetic factors that affect the milk yield of dairy animals (West, 1993). Our results agree with the results obtained by Igono *et al*. (1987), who found that cows cooled with spray and fan under shade produced 2 kg/cow per day more than cows in shade alone.

Treating lactating animals with cooling system significantly increased the average of milk fat and total solids percentages but not the milk protein. It is worth mentioning that cooling buffalo cows during the hot weather of summer months increased milk fat percent to attain an average of 10.37 %, which exceeded its average value during winter, spring and autumn. This is considered a very important result from the economic point of view, since farmers raise buffaloes essentially to get fat, which is converted into butter to be sold during winter months. Buffalo milk contains less water, more total solids, more fat, slightly more lactose and more protein than cow's milk. It seems thicker than cow's because it generally contains more than 16 % total solids compared with 12-14 % for cow's milk. In addition, its fat content is usually 50-60 % (or more) higher than that of cow's milk.

Blood metabolites

Cooling animals during the hot climate of summer season increased the average of either haemoglobin level, and count of red or white blood cell to the extent of the highest values when compared to other seasons of the year. Our results agree with the results obtained by Vijayakumar *et al*. (2011), who found that Murrah buffalo heifers provided with fan and sprinkling had significantly higher haemoglobin values compared to the animals with only a fan and the control group. Many authors (Shebaita and Kamal, 1973, and Marai *et al*., 1995) found that haemoglobin concentration decreases during heat stress due to either depression or hematopoiesis.

Effect of water spray on blood constituents related to metabolic activities of buffalo cows

The highest level of total lipid and cholesterol in treated groups could be attributed to increase in feed intake as a result of cooling their bodies. These results are in agreement with Johnson (1980), who reported that water spray and wind in hot humid environments significantly increased feed intake and T3 hormone in lactating cows. Verma *et al*. (2000) showed marked decrease in blood total lipid and cholesterol concentrations of lactating Murrah buffaloes during the summer than during the winter season. Also, they mentioned that the marked decrease in cholesterol concentration during heat stress may be due to dilution as a result of the increase in total body water or to the decrease in acetate concentration, which is the primary precursor for the synthesis of cholesterol. Also, Chaudhary *et al*. (2015) observed that exposure of lactating Surti buffaloes to hot humid and hot dry weather was associated with significant decrease in glucose and cholesterol. In the present study, significant increase in levels of plasma total proteins and albumins was observed as result of water spray. However, no significant effect was detected due to the treatment applied on the plasma globulin level. In buffalo calves, the heat stress conditions induced significant decreases in total protein concentrations (Habeeb *et al*., 2007). Serum total proteins were estimated as 44 $g.L^{-1}$ in summer and 51 $g.L^{-1}$ in winter by El-Masry and Marai (1991) in Egyptian buffalo calves. In lactating Murrah buffaloes, total blood proteins were lower during the summer season than during winter (Verma *et al*., 2000). In the study of Vijayakumar *et al*. (2011), provision of Murrah buffalo with fan and sprinkling had significantly higher total protein values when compared with the control group.

CONCLUSION

Providing Egyptian buffaloes with water spray to cool their bodies reduced the adverse effect of heat stress during the period of highest THI. Milk yield and composition were affected by water spray during the hottest period of the day. Environmental modification through water spray are associated with both haematological and biochemical responses in cooled buffaloes.

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