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Effects of Heat Reflective Roof Coating on Indoor Microclimates and Blood Parameters in Japanese Black Cattle

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Abstract:- The aim of this study was to assess the influences of heat reflective roof coating on indoor microclimate of building and blood serum biochemical parameters. Half of the building roof was coated with heat reflective coatings to investigate microclimate compared to non-coated roof for eight consecutive days. Collected blood samples from animals in both microclimate were divided into, control; under not-coated roof (n = 253) and treatment; under coated roof (n = 292) groups. The significant differences ($P < 0.05$) obtained for each parameters in both microclimate. The temperature and THI were significantly ($P < 0.05$) lower in treatment compared to control indoor environments, wherase the relative humidity was significantly ($P < 0.05$) higher in treatment indoor microcliamte. Studied blood parameters were not affected by indoor microclimate except for total colesterol and calcium which obtained significantly ($P < 0.05$) higher in treated indoor microclimate. These results demonstrated that heat reflective coating decrease heat invasion to inside the shelter and make effective way to modify microenvironment, and more attempts are needed to investigate blood parameters which were not affected by indoor microclimate variations.

I. INTRODUCTION

Heat stress is an environmental hazard for all live beings and massively jeopardize animal health. Heat stress reduce feed intake and its adverse effect starts from changes in behavior resulting to suppress productivity, physiological and reproductive activities, and finally reach beyond to death limit. Increased environmental temperature and humidity play a role as major barriers on sheep productivity in tropical and subtropical areas (Marai and Haeeb, 2010). High body temperature and respiraton rate are the most significant signs for heat stres in goat (Hashem et al., 2013). Heat stress results of irregularity of reproductive functons in Holstein friesian (Roth et al., 2002), reduce fetal growth in dairy animal (Collier et al., 1982), oxidative stress and enzymatic dysfunction (David et al., 2001), electorlyte imbalances in dairy cows (West et al., 1991), reduced meat quality of beef cattle (Kadima et al., 2004), and massive economic losses resulting from increased mortality and decreased overall animal performance (Hahn and Mader, 1997). A normal body temperature is the most important for physiological adjustment and to avoid hyperthermia (Lowe et al., 2001). In high ambient temperature animals increasingly reliant on evporative cooling in the form of sweating and panting to alleviate heat stress (Kimothi and Ghosh, 2005)

Nutritional, climatic, environmental and social stressors are likely to reduce welfare and performance of animals (Freeman, 1987), adopting to heat stress needs the physiological integration of many organ system such as endocrine, cardorespiratory and immune systems (Altan et al., 2003). The ratio of heterophil/ lymphocyte has been accepted as a reliable index to detect stress in animals which is found to increase as a result of stress (Gross and Siegel, 1983). Heat stress results in dramatic reduction in roughage intake, gut mortility and rumination which contribute to either decreased volitle fatty acid and may to alteration in acetate: propionate ratio. Rumen pH also decrease during thermal stress (Collier et al., 1982). In spite of all, heat stress have potential effect to activate hormonal glands, increase plasma concentration of cortisol and corticosterone and less frequent increase in epinephrine and nor epinephrine concentration in heat stressed animals (Minton, 1994). High envrionmental temperature results functional and metabolic alterations in cells and tissues including cells of immune system. In this condition, the administration of antioxidants has proved useful for improvement of immune functions (Victor et al., 1999).

The influnces of heat stress are costly to farmers, there are some approach to recover some of the losses due to hot weather. Physical modification of evironment, genetic imrovement of breeds and nutritional management are the three major key components to sustain production in high ambient temperature (Beede and Collier, 1986). Shading is the cheapest ways to modify an animal's evironment during hot weather, eventhough shade reduce heat accumulation, not effecting air temperature or relative humidity and cooling is required for farm animals in hot humid climate (Kimothi and Ghosh, 2005). Livestock management tools usage could help for modifying the microenvironment to enchance heat dissipation mechanism and relieve heat stress.

The metabolic profile concept in dairy cows has created and used intially in Britain (Payne et al., 1970). The main expected reason of success was supposed that all biochemical values in bovine blood will reflect feed intake

(Parker and Blowey, 1976). The metabolic profile test (MPT) was initially designed as a pre-symptomatic diagnostic tool or health condition indicator based on statistical analyses of blood metabolites which is capable to provide an early alert of certain types of metabolic disorders (Da et al., 2015). Its usage is gaining a wider application as animal response indicator to detect animal physiological, nutritional, metabolic disorders and health condition. The assessment of nutritional status by metabolites values are becoming popular (Ndlovu et al., 2007) because of automated laboratory testing machines and the ease of taking blood samples, and considered more important in evaluating the health status of animal. There are numerous sources of variablitiy, other than nutrition, an important non- factors such as breed (Tong et al., 1986), age (Otomaru et al., 2016), sex (Carlos et al., 2015), seasons (Beran and Ulker, 2006) and physiological changes (Otomaru et al., 2015) can affect the blood serum parameters, and make difficulties in interpretation of the results.

There are lack of informations regarding the heat reflective roof coating usage for declining heat stress adverse effects on animals. Therefore the present study was conducted to evualvate the influences of heat reflective roof coating on blood parameters of doemestic breed (Japanese black fattening cattle) and indoor microclimate under hot environmental conditions.

II. MATERIALS AND METHODS

The study protocol and all experimental procedures involving animals were approved and conducted in accordance to the guideline for the experimental animal care and use of University of Miyazaki. Half of Japanese black beef cattle house roof was coated with heat reflective coating and used as treatment, and the rest not-coated roof used as control for the investigation of effects on indoor microclimate during 5/08/2016-13/08/2016. The animal house was located east to west direction contained 38m length, 15.7m width and shed height (roof height) above the feeding lane about 10m and declined (sloped) by 30º to 6m above the ground at its low boundaries oriented from south to north, the ridge roof was made of slate. Continuous measurements of air temperature and relative humidity in both indoor microclimate of the building were recorded by TR-73U thermo-recorder (data logger capable of measuring, displaying and recording temperature, humidity, and barometric pressure data) at 2 minutes intervals. This device recorded simultaneously temperature and humidity measurements detected by attached sensors, these data loggers were installed in parallel form at the one side of corridor between the stalls in the mid of building with 2.5 meter height from the floor. The temperature humidity index used as indicator of thermal comfort for cattle 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).

A total of 36 animals were involved in the experiment for the investigation of indoor microclimate effects on blood serum biochemical parameters from July to October in 2015. Animals were fed a diet Table 1. formulated according to the standard tables of feed composition in japan and in each stall fresh potable water was available ad libitum.

Item	Composition %	DM (kg/100kg)	TDN%	CP%
Corn	23.0	19.9	18.4	1.7
Barley	32.0	28.2	23.8	3.4
Wheat bran	20.0	17.7	12.5	3.1
Wheat bran with flour	20.0	17.4	14.8	2.8
Soybean meal	2.5	2.2	1.9	1.1
Shochu distillers residue (dried sweat potato)	1.0	0.9	0.5	0.2
Calcium carbonate	1.5	1.5	0.0	0.0
Vitamin additive				
Total	100.0	87.8	71.9	12.5

Table 1:- The ingredients of concentrate for fattening cattle.

After a proper restraining and humane handling for the safety, blood samples were obtained once per month by external jugular venipuncture using plain vacuum tubes in morning. The tubes were inverted several times to ensure proper mixing. After proper clothing, the tubes were centrifuged (3000rpm for 20minutes) and harvested serum shipped immediately and stored at frozen state (-20ºC) until analysis.

The following blood serum metabolites concentrations; Glutamic oxaloacetic transaminase (GOT), glutamic pyruvate transaminase (GPT), albumin (ALB), total cholesterol (T-Cho), total protein (TP), blood urea nitrogen (BUN) and calcium (Ca) were measured by using an auto colorimetric analyzer (DRI-CHEM 7000, Fuji Medical Systems) with commercially available kits in this experiment. Statistical significant difference between two

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each parameters were determined by Wilcoxon rank sum test. Both data were tested by using R x64 3.3.1 for windows. The level of significance was set at (P < 0.05).

III. RESULTS

The recorded data by thermo-recorder TR-73U for indoor microclimates during experimental period analyzed and significant differences (P < 0.05) obtained for temperature, relative humidity and temperature humidity index in two micro-climates inside the fattening house. The temperature was lower in under heat reflective coated roof compared to under not-coated roof microclimate. In experimental period, the temperature and relative humidity had adverse effect on each other. In high temperature, the relative humidity was getting decreased, and vice versa. Hence, the temperature was lower in under heat reflective coated roof but relative humidity and temperature humidity index were higher in comparison to under not-coated roof microclimate.

Summary of daily monitored micro-climate conditions in two compartment inside the fattening house defined with use of basic descriptive statistics. Average and Standard deviation values of two indoor micro-climate inside the fattening house based on heat reflective coated (treatment) and non-coated roof (control) recorded during experimental period at daytime shown in Table 2.

Environmental conditions					
Control			Treatment		
Temperature	Relative humidity	THI	Temperature	Relative humidity	THI
31.59 ± 2.37	70.65 ± 12.14	83.54 ± 1.99	30.84 ± 1.99*	73.58 ± 11.26*	82.96 ± 1.71*

*: indicate mean values significant difference (P < 0.05) for each related individual of indoor microclimates conditions.

Table 2:- Average (±SD) values of indoor microclimate conditions under coated and non coated roofs.

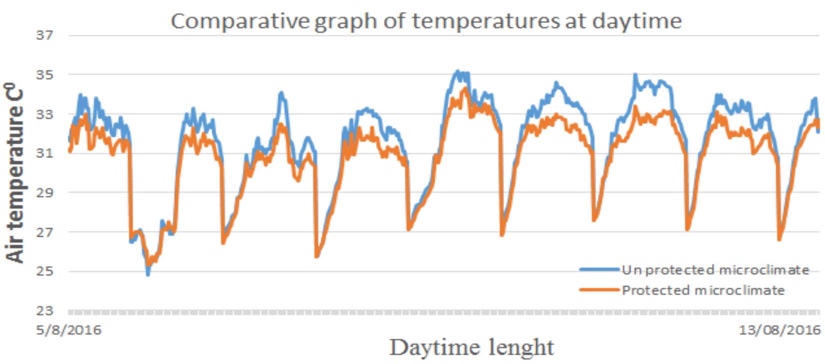

Fig 1:- Comparative graph of two microclimate temperatures.

The temperature at daytime was recorded and had significant (P < 0.05) difference in two separate chambers (control, treatment), the graph shows the declined temperature degree at morning and evening time but at noon, the temperature rapidly increased and the most obvious difference is clearly visible between protected and unprotected chambers at high temperature.

The blood serum metabolites investigated in two different micro-climate inside the fattening house, the mean of Glutamic-oxaloacetic transaminase value was slightly higher in unprotected group in comparison to heat protected group as well as Glutamic-pyruvate transaminase and Albumin. Total protein and Calcium value were also obtained similar with a bit differentiation. On the other hand, the blood urea nitrogen mean value was against the result obtained for the rest of parameters, its mean value was slightly decreased in unprotected group. None of these difference reached statistical significance in coated and not-coated roof groups during experimental period except for total cholesterol and calcium. These were significantly (P < 0.05) lower in unprotected chamber.

Parameters	Under heat reflective	
	Not-coated roof (n=253)	Coated roof(n=292)
Glutamic-oxaloacetic transaminase	57.16 ± 25.37	57.27 ± 25.94
Glutamic-pyruvate transaminase	23.20 ± 4.50	23.62 ± 4.81
Albumin	3.35 ± 0.32	3.36 ± 0.32
Total Cholesterol	135.00 ± 32.07	147.89 ± 33.99*
Total Protein	6.48 ± 0.89	6.49 ± 0.92
Blood Urea Nitrogen	16.13 ± 9.47	15.49 ± 2.86
Calcium	9.21 ± 1.01	9.28 ± 1.05*

*: Indicates significant difference (P < 0.05).

Table 3:- Average (±SD) obtained values of all studied blood serum parameters in under heat reflective coated and not-coated roof groups.

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IV. DISCUSSION

The main aim of the study was to assess the possible apparent effect of heat reflective roof coating on indoor microclimate and blood serum parameters in Japanese black fattening cattle. There are no reliable more details in literatures about this section and to add existing knowledge to benefit engaged people of veterinary field.

Heat reflective coating had effects on indoor microclimate and could be used to provide optimum environment for animals, it is cheapest, long lasting and easiest way, although, other options such as genetically less sensitive breeds selection and nutritional management also make the key components to sustain production in hot environment (Beede and Collier, 1986). In spite of it, it has been reported that shade reduces heat accumulation but no effect on air temperature or relative humidity, so additional cooling is necessary for farm animals in a hot humid climate (Kimothi and Ghosh, 2005).

The THI stress index is suitable for measurements of the thermal environment and assessments of its effects on cattle (Kibler, 1964). In our findings, the mean of microclimate THI in both chambers were in moderate thermal stress level (moderate stress 79-89. There is genetic variation for cooling capability among animals, which recommends that more heat tolerant animals can be selected genetically (Sunil Kumar et al., 2011). Japanese black fattening cattles are originated and make a sole domestic farm animals in Japan (Namikawa, 1982), due to their adaptability and natural selection, the blood parameters were not affected by indoor microclimates except for total cholesterol and calcium. Even though, the dark skin animals are more susceptible to heat stress and exhibit signs of great distress (Das et al., 2013). The total cholesterol value decreased in control (high temperature) compared to treatment (low temperature) groups of animal, the similar result reported by (Habeeb et al., 1996; Hooda and Singh, 2010) when animal exposed to direct solar radiation. Calcium level increased value observed in Holstein and Jersey cows but lowered in Australian milking zebu (Srikandakumar and Johnson, 2004), it could be the difference of breeds and adaptability, and high value in our findings might be due to high feed intake or liking of mineral block in treated environment compared to control.

V. CONCLUSION

It can be concluded from the experiment that heat reflective coated roof decrease heat invasion to inside the shelter and could be effective way to modify the microenvironment, enhance heat dissipation mechanism for relieving heat stress, and to obtain optimum environment for better performance of animals. The noticeably variation in total cholesterol might be due to difference of temperature in microclimates as reported in previous literature but Calcium amount variation remains elusive and needs further more investigation.

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