

Potential Impact of Temperature and Humidity on Milk Yield of Holstein Friesian Crossbred Dairy Cows

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ABSTRACT

This study was an attempt to find out the correlation among Temperature Humidity Index, milk yield, milk fat and SNF percentage at first lactation of Holstein Friesian (HF) crossbred (50% HF and 50% local) dairy cows in comparatively cooler months in the coastal areas in Bangladesh. Sixty HF crossbred cows at the early lactation stage were selected randomly from ten farms. Milk samples were collected from cows at seven days intervals and stored at 4 °C until further analysis. Data on temperature and relative humidity were collected from metrological records from late September to December 2019. The results revealed that milk yield, fat, and SNF percentage significantly differed from the THI recorded in different months. It was also observed that there was a significant ($p < 0.05$) negative correlation between THI with milk yield, milk fat, and SNF percentage. In conclusion, the result revealed that THI greatly affects HF crossbred dairy cows' milk yield and composition in comparatively cooler months.

Keywords: cooler month, coastal, crossbred, milk yield, THI.

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I. INTRODUCTION

Heat stress potential is gradually escalating as global temperatures rise, both in absolute terms and in terms of duration. Extreme heat events are predicted to occur more frequently as a result of climate change, which would lower agricultural and pasture output in many areas and increase the incidence of heat-related animal productivity losses, endangering the health and well-being of animals [1].

Environmental factors such as temperature, relative humidity, solar radiation, air movement, and precipitation all greatly contribute to heat stress in dairy cows. The temperature-humidity index (THI) is a single value that represents the combined effects of temperature and humidity on the degree of heat stress [2]. The high ambient temperature is a major factor causing jeopardizing animal productivity in tropical, subtropical, and arid regions [2]. Heat stress affects milk production when THI values are higher than 72, or 22 °C at 100% humidity, 25 °C at 50%

humidity, or 28 °C at 20% humidity. THI thresholds for heat stress in cattle were reported as follows by [3]: comfort ($THI < 68$), mild discomfort ($68 < THI < 72$), discomfort ($72 < THI < 75$), alert ($75 < THI < 79$), danger ($79 < THI < 84$) and emergency ($THI > 84$). According to Brügemann *et al.* [4], depending on the location, milk yield decreased by 0.08 to 0.26 kg for each unit increase in THI. Milk production and feed intake are negatively correlated with the daily THI ($r = -0.76$ and $r = -0.24$, respectively) [5], [6]. The same authors found that for every point higher in the $THI > 69$, milk production dropped by 0.41 kg per cow per day. During hot weather, DMI decreased by 0.85 kg for each degree (°C) increase in the mean air temperature, whereas milk production for Holsteins decreased by 0.88 kg per mean THI unit [7]. In addition to declines in feed intake and milk yield, as the world's temperature is rising [1] heat stress has been identified as a major factor affecting the quality of milk from dairy cattle [8]. The severity of heat stress effects on cows will increase as climate change and global warming escalate and this impact will be felt more among producers with a subsistence economy in tropical regions of developing countries [9]. Over 50% of the cattle population is located in the tropics and it has been appraised that heat stress causes severe economic loss in approximately 60% of dairy farms around the world [8]. The effects are more pronounced in high-producing cows. In a tropical country like Bangladesh, [10] found a significant impact of heat stress on the yield and composition of Holstein Friesian crossbred cows. It is highlighted that during early lactation milk production and composition are greatly affected by heat stress [11]. At present, many small and medium-scale dairy farmers are raising high-yielding dairy cows, especially HF crossbred in Bangladesh [12]. However, higher ambient temperature and relative humidity greatly affect the milk production of these crossbred cows. Bangladesh has a tropical climate in the south and a subtropical climate in the center north with a winter from November to February and a summer monsoon from June to October. Some researchers have tried to find out the effect of different levels of THI on milk yield and composition in the warmer seasons in different parts of Bangladesh except the coastal region. In our study, we tried to focus on the comparatively colder months of the southern part of this country to observe any heat stress effects on the dairy cow's productivity. Therefore, in this study, the objective was to investigate the effect of THI on milk yield and its composition at the first lactation of HF crossbred dairy cows in cooler months in the coastal region of Bangladesh.

II. MATERIALS AND METHOD

A. Animal, Diet, and Collection of Milk Sample

Sixty Holstein-Friesian crossbred (50% Holstein Friesian, HFX) cows at their early lactation stage were selected from ten small-scale dairy farms from five districts in the Barishal division (22.3811° N, 90.3372° E). The cows were fed mixed green grass (existing practices) and a concentrated mixture (2 kg/h/d). The concentrate ingredients were wheat bran, rice polish, mustard oil cake, common salt, and di-calcium phosphate (DCP). All cows had free access to clean,

drinking water all the time. The cows were kept in a well-ventilated barn and milked twice a day at 7.00 am and 5.00 pm. Milk samples were collected from cows at seven days intervals and stored at 4°C until chemical analysis.

B. Calculation of Temperature-Humidity Index (THI)

Temperature and Relative Humidity were recorded regularly from September 25 to December 15 in 2019. Animal heat stress risk can be determined using a variety of methods. To measure the thermal comfort of animals, these approaches include the use of indices that integrate measurements of ambient temperature and relative humidity [13]. The most recognized index, THI which was used in this study and a lot of literature is based on the Thom [14] equation (1959):

$$THI = 0.8 \times T + ((RH / 100) \times (T - 14.3)) + 46.4 \quad (1)$$

where:

T – the dry bulb air temperature (°C),

RH – the relative air humidity (%).

TABLE I: THE THRESHOLD VALUE OF THI FROM [14] EQUATION TO ESTIMATE THE HEAT STRESS OF CATTLE

Species	The onset of heat stress level			References
	Moderate	High	Extreme	
General	70	75	80	[14]
Cattle:				[15]; [16];
Dairy	72	79	89	[17]; [18];
				[19]
Cattle:				[20]
General	72	79	90	
Cattle: Beef	72	82	94	[21]

Note: This information was adapted from the study reported by [22].

C. Chemical Analysis

Milk samples were analyzed for fat content and solids-not-fat (SNF) by the Gerber method and Richmond's formula, respectively at the Dairy Science lab of Patuakhali Science and Technology University.

D. Statistical Analysis

The average mean and standard deviation of THI, milk fat, and SNF percentage from each month and the correlation among THI, milk fat, and SNF percentage were analyzed by IBM SPSS Statistics 20.

III. RESULTS

A. Changes in Milk Yield, Fat, and SNF Percentage with THI

It was found that the THI index differed significantly ($p < 0.05$) among the observed months (Table II). The highest THI (79.15) was recorded in September and the lowest (66.37) in December. The observed THI in the other two months, October and November were 78.37 and 76.0, respectively. It is indicated that increasing THI caused a significant ($p < 0.05$) decrease in milk production, milk fat, and milk SNF percentages (Table II). The average milk fat and SNF percentage were found to be the highest in December at 3.51 and 8.98, respectively, and lowest in

September at 3.37 and 8.79, respectively, and these resulted from the influence of the THI recorded.

TABLE II: MONTH AVERAGE THI AND MILK YIELD (L/D), FAT (%), AND SNF (%)

	THI	MY	Fat	SNF
THI	1			
MY	-0.99**	1		
Fat%	-0.95**	0.92**	1	
SNF%	-0.53	0.61	0.26	1

**significant at 1% level ($p < 0.01$), MY= Milk Yield.

Fig. 1 demonstrates the weekly variation of milk yield with the changes in THI. It is indicated that milk yield was in an increasing trend with the months of decreasing THI values. Hence, milk yield was comparatively higher in December and lower in September, even greatly fluctuating weekly with the THI in the same month.

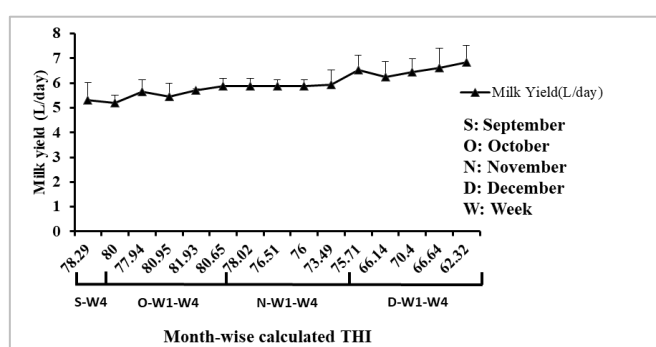


Fig. 1. Variation in milk yield with THI.

Fig. 2 depicts the changes in milk fat and SNF% against the THI during the observed month. It was found that the THI values changed among the months where the higher values were recorded in September and October compared to November and December. Similarly, milk fat and SNF % followed the opposite trend as higher percentages were seen in the months of November and December compared to September and October.

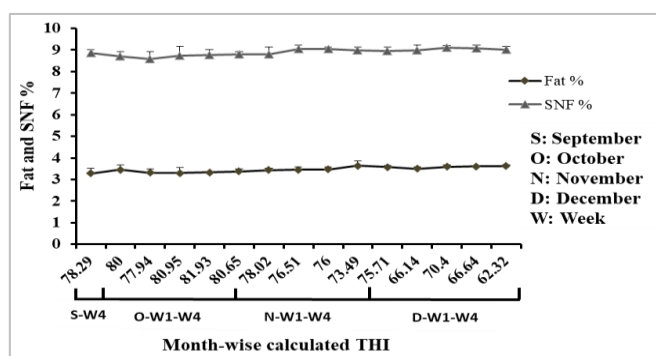


Fig. 2. Change in Milk Fat and SNF %.

The slope is the rate of decline in milk yield, and the regression indicated that for each point increase in the THI value, there was a decrease in milk yield of 0.12 kg/cow/day (slope -0.12) (Fig. 3). The recorded THI difference from December to September was 8.22, reducing milk production by 17.68%. The slope of Fig. 4 and Fig. 5 indicated that fat and SNF percentage decrease at a rate of 0.05 and 0.03 percent with the increase of per unit THI index. From the

correlation, it is clearly indicated that increasing THI caused a significant ($p < 0.05$) decrease in milk production (Table III).

TABLE III: CORRELATION AMONG THI, MILK YIELD, FAT (%), AND SNF (%)

Month	THI	Milk yield	Fat	SNF
September	79.15± 1.209	5.26± 0.461	3.37± 0.016	8.79± 0.011
October	78.37± 1.708	5.67± 0.378	3.4± 0.011	8.72± 0.007
November	76± 1.883	5.8± 0.332	3.5± 0.001	8.97± 0.012
December	66.37± 6.786	6.39± 0.558	3.51± 0.008	8.98± 0.012
LS	*	*	*	*

LS=Level of Significance; *significant at 5% level ($p < 0.05$).

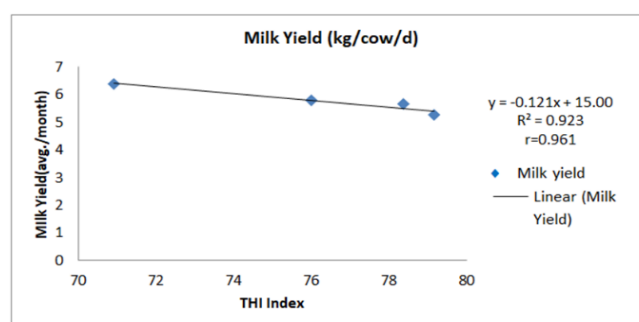


Fig. 3. Relationship between milk yields with THI.

Regression coefficients are significant at $p < 0.05$. R^2 =coefficient of determination. r =coefficient of correlation.

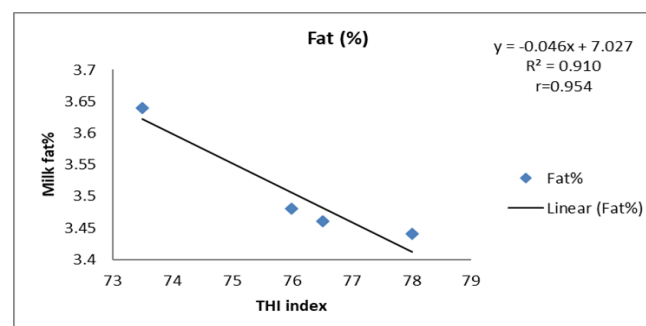


Fig. 4. Relationship between milk fat percentages with THI. Regression coefficients are significant at $p < 0.05$. R^2 =coefficient of determination. r =coefficient of correlation.

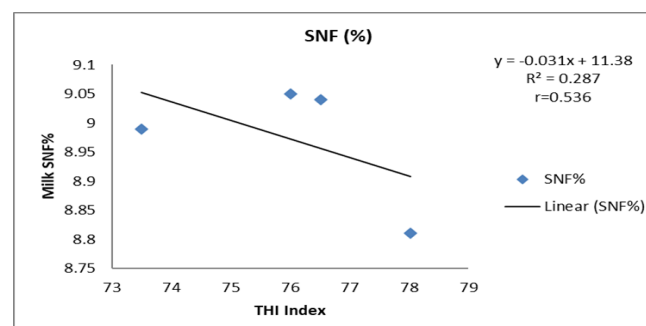


Fig. 5 Relationship between milk solids not fat percentage with THI. Regression coefficients are significant at $P < 0.05$. R^2 =coefficient of determination. r =coefficient of correlation.

IV. DISCUSSIONS

A. Average THI, Milk Fat, and SNF Percentage

Decreased dry matter intake and feed conversion efficiency caused by thermal stress directly impact animals' body conditions, resulting in low milk yield [7]. In a study, [19] quoted the moderate THI for cattle as 72, high as 79, and extreme as 89 (Table I). In another study, [3] stated that the comfort THI for dairy cattle is below 68, mild discomfort is between 68 to 72 and danger is above 79. Our study found THI 79 in September and 78 in October, and 76 in November. In another study, [10] reported THI for September and October as 81 and 79 in our country which is in line with our findings. Here, it is clearly evident that the dairy cattle in our country undergo heat stress even in the winter months likewise summer months. The result of this study indicated that the milk yield was highly impacted by the THI levels and increased THI significantly decreased milk production. The results from this study are consistent with the findings of [10] who reported lower milk yield with higher THI records. Internal metabolic heat production during lactation can reduce the resistance of cattle to high ambient temperatures, resulting in altered milk composition and a reduction in milk yield [23]. Lactating dairy cows in high ambient temperature and high relative humidity for extended periods decreases their ability to dissipate heat generated from both metabolic processes and the heat gained from the environment, making them susceptible to heat stress [24], [8]. To decrease its heat load, the cow reduces feed intake and milk production [25]. In a study, it was reported that heat stress reduced milk yield by 4.16% to 14.42% across THI groups, with daily milk yield being the highest in the THI range 61–66 (7.40 L) and the lowest in the THI range 79–81 (6.33 L) [26]. Even in well-cooled dairies or intemperate areas, heat stress decreases milk yield by 10–15% and in non-cooled management systems, milk yield can decrease by as much as 40–50% [27], [28].

The study observed that milk components such as milk fat and SNF% were also increased as the temperature and humidity tended to decline from September to December. Hot and humid environments affect milk yield and quality and fat, and solids-not-fat (SNF) percentages decreased by 39.7% and 18.9 %, respectively, reported by [29]. Significant decreases in milk fat yield under heat stress conditions have been reported in several studies [30], [31]. Declines of 0.02 kg/d of fat percentage were observed when cows were heat-stressed for 1 d or 2 consecutive days [31]. In another study, the decrease in fat percentage reached a maximum of 0.06 kg (6%) when cows were exposed to heat stress for 7 or 8 consecutive days [32].

V. CONCLUSION

The THI index has been identified as one of the major factors influencing the quality and quantity of milk, especially for HF crossbred dairy cows in tropical and subtropical climates. The current study revealed that the THI index greatly influences the milk quantity and fat yield of HF crossbred cows in comparatively cooler seasons in coastal belt areas. With the improving the feeding, breeding, and other management, taking care of higher temperatures

and humidity would improve milk production along with milk fat yield.

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CONFLICT OF INTEREST

The authors declare no conflict of interest with any financial or personal relationship.

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