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Research Article

# Impact of Heat Stress on Growth Performance and some Blood and Physiological Parameters of Suckling Friesian Calves in Egypt

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## Abstract

Forty newly born male and female Friesian calves including 20 calves during the winter season and 20 calves summer season 2020, were used to study the effect of heat stress on live body weight, body weight gain, feed intake, feed and economic efficiency during suckling period. Ambient temperature, relative humidity and temperature humidity index were markedly higher during summer in compression with winter season. Digestibility coefficients of all nutrients (DM, OM, CP, CF, EE and NFE) and feeding values (TDN and DCP) reduced significantly (P<0.05) for summer ration compared to winter ration. Ruminal pH value and ammonia nitrogen concentration were higher significantly (P<0.05), however total VFA concentration was lower significantly (P<0.05) for summer than winter season. Concentrations of serum total protein, globulin and glucose were higher significantly (P<0.05), however, albumin to globulin ratio, concentrations of urea and creatinine and activity of AST and ALT activity were lower significantly (P<0.05) for winter season compared to summer season. Hemoglobin (HGB) concentration and counts of white blood cells (WBC) and red blood cells (RBC) were declined significantly (P<0.05), however, haematocrit percentage (HCT), mean cellular volume (MCV), mean cellular hemoglobin (MCH) and mean cellular hemoglobin concentration (MCHC), were raised significantly (P<0.05) for summer season than those of winter season. Intake of TDN, CP and DCP were higher significantly (P<0.05) for winter season than those of summer season. Weaning weight, total weight gain and average daily gain were higher significantly (P<0.05) for winter season in comparison with summer season.

The amounts of DM, TDN, CP and DCP per kg weight gain were lower significantly (P<0.05) for summer season compared to winter season. Feed cost per kg weight gain was higher significantly (P<0.05), however, output of ADG, net revenue and economic efficiency were higher significantly (P<0.05) for winter season than those of summer season. All physiological parameters such as rectum temperature (RT), skin temperature (ST), respiration rate (RR) and pulse rate (PR) were higher significantly (P < 0.05) during the summer compared to the winter season.

**Keywords:** Suckling Friesian calves; Heat stress; Feed intake; Digestibility; Rumen fermentation; Blood parameters; Growth rate; Feed and economic efficiency; Physiological parameters

## 1. Introduction

Introduction in general, Egypt's summer is characterized by high ambient temperature and relative humidity (RH) resulting in heat stress (HS) which everywhere affects the productive performance of livestock species. Oxidative stress (OS) is an increase in the generation of reactive oxygen species (ROS) more than the ability of the body's antioxidant physiological mechanisms to conduct safe neutralization [1].

The Earth's climate is expected to change continuously at exceptional rates in recent decades [2]. The summer temperature in the Mediterranean region, including Egypt, is generally outside the cow's "comfort zone" resulting in HS. The term HS is defined as the sum of the accumulated heat from the environment and the animal's failure to dissipate heat, which is often associated with a defect in the animal's productive and/or physiological metabolism [3].

Plenty of authors studied the physiological reactions of different cattle breeds to natural environmental conditions under different housing systems. There was a great deal of agreement between their results. Cattle body reactions were related to temperature humidity index (THI) [4]. Body reaction values increased linearly with increasing air temperature. The values of rectal temperature (RT), skin temperature (ST) and respiration rate (RR) showed high correlations with air temperatures [5-7].

Outside the comfort zone, the animal experiences stress to remain homoeothermic [8]. Changes in blood metabolites levels due to exposure of animals to air temperature have been studied by several [9, 5, 6, 10]. The difference between normal and lethal body temperature is in the order of 15-25 oC in the cold and of only around 3-6 ℃ in the heat. This explains why cold represents fewer problems than heat [11].

The small numbers of studies seasonal effects of growth in dairy calves all agree on a lower average daily weight gain in seasons with higher ambient temperature [12-14]. The lower growth rate is mainly attributed to lower intake of neonates in the hottest period of the year [15, 16], rather than the consequences of maternal heat stress. Given that dry cow heat mitigation is an overlooked area in dairy farms, it is tempting to speculate that the effects of prenatal heat stress may mask postpartum heat stress responses. However, postpartum thermal conditions (cooling versus no refrigeration) have been shown to dominate the well-being and performance of calves in the pre-weaning period, regardless of prenatal thermal status (cooled versus non-cooled dams) [17].

Growth performance deteriorated due to exposure to high air temperature or artificial heat stress experimentation [18, 19]. The main objective of this study was to evaluate the effects of heat stress during summer season on feed intake, digestibility, rumen activity, some blood biochemical and hematological, growth rate, feed conversion ratio, economic efficiency and physiological responses of suckling Friesian calves.

## 2. Materials and Methods

The current work was carried out at Karada Animal Production Research Station, belonging to Animal Production Research Institute, Agricultural Research Center, Ministry of Agriculture, Egypt.

### 2.1 Temperature humidity index

Temperature humidity index (THI) index was calculated for winter season (January, February, March) and summer season (July, August, September) 2020 using the formula developed by Kibler (1964) [20], as follows: THI = ((0.8*T) + H/100*(T-14.4) + 46.4), where T is ambient temperature and H is relative humidity.

### 2.2 Experimental animals

Forty newly born male and female Friesian calves including 20 calves during the winter season (January, February, March) and 20 calves summer season (July, August, September) 2020, were used to study the effect of heat stress on live body weight, body weight gain, feed intake, feed and economic efficiency during suckling period.

### 2.3 Experimental rations

Calves were fed whole milk, calf starter and fresh berseem during winter season and whole milk, calf starter and berseem hay during summer season. Claves were fed to cover their recommended requirements for suckling calves according to NRC (2001) [21] as shown in Table 1. Chemical composition of whole milk, starter, fresh berseem and berseem hay are presented in Table 2.

| Season | Ambient temperature °C | Relative humidity % | Temperature humidity index (THI) |
|---|---|---|---|
| Winter | - | - | - |
| January | 13.95 | 59 | 57.29 |
| February | 15.15 | 58 | 58.96 |
| March | 17.05 | 56 | 61.52 |
| Summer | - | - | - |
| July | 28.35 | 78 | 79.96 |
| August | 28.15 | 81 | 80.06 |
| September | 26.55 | 80 | 77.36 |

**Table 1:** Ambient temperature, relative humidity and temperature humidity index for winter and summer seasons.

| Age | Whole milk | Starter | Fresh berseem | Berseem hay |
|---|---|---|---|---|
| 1-3 days | Suckling their dams colostrum | | | |
| | Kg/head/day | | | |
| 4-7 days | 3.5 | - | - | - |
| Week 2 | 4.0 | 0.10 | - | - |
| Week 3 | 4.5 | 0.25 | 1.0 | 0.1 |
| Week 4 | 5.0 | 0.25 | 1.0 | 0.1 |
| Week 5 | 5.0 | 0.50 | 1.5 | 0.2 |
| Week 6 | 4.5 | 0.50 | 1.5 | 0.2 |
| Week 7 | 4.0 | 0.75 | 2.0 | 0.3 |
| Week 8 | 3.5 | 0.75 | 2.0 | 0.3 |
| Week 9 | 3.0 | 1.00 | 2.5 | 0.4 |
| Week 10 | 2.5 | 1.00 | 2.5 | 0.4 |
| Week 11 | 2.0 | 1.25 | 3.0 | 0.5 |
| Week 12 | 1.75 | 1.25 | 3.0 | 0.5 |
| Week 13 | 1.5 | 1.50 | 3.5 | 0.6 |
| Week 14 | 1.25 | 1.50 | 3.5 | 0.6 |
| Week 15 | 1.0 | 1.75 | 4.0 | 0.7 |
| Total | 318.5 | 86.45 | 217 | 34.3 |
| Average | 3.03 | 0.82 | 2.06 | 0.33 |

**Table 2:** Daily allowances of whole milk, starter, fresh berseem and berseem hay (kg) for suckling Friesian calves.

| Items | DM % | Composition of DM % | | | | | |
|---|---|---|---|---|---|---|---|
| | | OM | CP | CF | EE | NFE | Ash |
| Feedstuffs | | | | | | | |
| Whole milk | 12.65 | 94.31 | 25.30 | 00.00 | 30.04 | 38.97 | 5.69 |
| Starter* | 91.70 | 91.60 | 17.75 | 5.80 | 3.45 | 64.60 | 8.40 |
| Fresh berseem | 15.60 | 88.20 | 16.50 | 23.50 | 3.35 | 44.85 | 11.80 |
| Berseem hay | 89.45 | 92.35 | 12.80 | 28.70 | 2.65 | 48.20 | 7.65 |
| Rations | | | | | | | |
| Winter | 24.65 | 91.56 | 19.46 | 8.18 | 10.42 | 53.50 | 8.44 |
| Summer | 34.22 | 92.48 | 18.75 | 8.97 | 10.41 | 54.35 | 7.52 |

* Starter: 15% soya bean meal, 10% linseed cake, 34% ground corn grain, 20% wheat bran, 15% rice bran, 3% molasses, 2% limestone and 1% common salt.

**Table 3:** Chemical composition of tested feedstuffs and rations.

### 2.4 Management procedure

Calves were given whole milk in plastic bucket twice daily at 7 a.m. and 5 p.m. during winter season and at 7 a.m. and 7 p.m. during summer season. Calf starter was provided once daily at 9 a.m., while fresh berseem or berseem hay was introduced once daily at 11 a.m. Water was available in build basin for calves all the day round. Calves were weighed weekly in morning before feeding and body weight was recorded in nearest kg.

### 2.5 Digestibility trials

Two digestibility trials were conducted during suckling period at end week of suckling period using 6 calves in each trial (3 males and 3 females) to determine nutrients digestion coefficients and nutritive values of winter and summer rations use acid insoluble ash (AIA) as a natural marker [22]. Fecal samples were taken from the rectum of each calf twice daily with 12 hours interval for 7 days collection period. Whole milk, calf starter, fresh alfalfa and alfalfa straw were sampled at the beginning, middle and end of the collection period. Calf starter samples, fresh alfalfa, alfalfa straw and faces were composted and representative samples were dried in a forced air oven at 65 °C for 48 h, ground and analyzed according to AOAC (1990) [23].

Whole milk samples were analyzed using Milko-Scan (133B Foss Electric). The nutrient digestibility coefficients were calculated from the equations mentioned by Schnider and Flatt (1975) [24]. Total digestible nutrients (TDN) and digestible crude protein (DCP) were calculated according to the classic formula of McDonald et al. (1995) [25].

### 2.6 Rumen liquor samples

Rumen liquor samples were collected from calves used in digestibility trials at the end week of the suckling period at three hours after the morning feeding using stomach tube and filtered through double layers of cheese cloth. Ruminal pH value was immediately estimated using Orian 680 digital pH meter. The concentration of ammonia-N was determined using saturated solution according to the method of AOAC (1990) [23]. The concentration of TVFA's was determined in the rumen liquor by the steam distillation method according to Warner (1964) [26].

## 2.7 Blood samples

At the end of the suckling period, samples of blood were collected from the jugular vein of every calf by sterile needle in clean dry glass tubes in two parts. In the 1st section heparin was once used as an anticoagulant for decided hematological parameters. Whereas, the 2nd section used to be take a seat for 30-60 minutes at room temperature to clot. Then centrifuged for 15 minutes at 4000 rotations per minute to reap serum and stored in deep freezer at – 20 ℃ till analysis. Serum totals protein, albumin, glucose, urea, and creatinine, aspartate amino transferase (AST) and alanine amino transferase (ALT) were analyzed using commercial kits purchased from Diamond Diagnostics Company, Egypt.

Haematological parameters were performed within 4 hours using Procyte (IDEXX, SUA) blood cell counter according to the methods of Drew et al., (2004) [27]. White blood cell value (WBC), red blood cell (RBC), hemoglobin (HGB), hematocrit (HCT), mean body volume (MCV), mean muscle hemoglobin (MCH), and mean body hemoglobin concentration (MCHC). Feed conversion efficiency: Feed conversion efficiency was calculated as amounts of DM, TDN, CP and DCP per kilogram of live body weight.

## 2.8 Economic efficiency

Economic efficiency was calculated as the ratio between the income of average daily body weight gain and the cost of average daily feed consumed as well as the relative net revenue in compared to feed cost. Where, the price of 1 kg was 6 LE for whole milk, 5.5 LE for starter, 0.6 LE for fresh berseem, 3 LE for berseem hay and 70 LE for body weight gain through year 2020.

## 2.9 Physiological parameters

Rectal temperature (RT, ºC) was recorded using a digital thermometer while the measurements were recorded to the nearest 0.1 ºC. Skin temperature (ST) was measured using an infrared thermometer at the fore-flanks region. Respiration rate (RR, breaths /minute) was recorded by counting the flank's movements per 1-minute using stopwatch.

The pulse rate was also obtained with the aid of a flexible stethoscope, this time placed at the left thoracic region at the aortic arch, expressed in beats per minute. Data collection also occurred at 09.00 h and 15.00 h.

## 2.10 Statistical analysis

For statistical analysis, independent two samples T-test were performed using Minitab® 19 for windows (2019) [28]. A statistical significance was checked for p value, 0.05.

## 3. Results and Discussion

### 3.1 Environmental parameters

Environmental parameters recorded in terms of ambient temperature, relative humidity and temperature humidity index for winter and summer seasons are presented in Table (3). Environmental parameters exhibited wide variability during the two seasons, which the ambient temperature, relative humidity and temperature humidity index were markedly higher during summer in compression with winter season. Average THI values for winter and summer seasons were 59.26 and 79.13, suggesting that animals done under heat stress during summer season. The upper critical temperature for Holsteins is 25 ℃ [29]. Ben Salem and Bouraoui (2009) [30] reported that summer heat stress prevails in Tunisia for four to five months going from May to September with THI values being greater than 72.

The upper temperature for lactating cows was 25 ℃ and the relative humidity greater than 80% indirectly affects the upper critical temperature [31]. The temperature humidity index (THI) is commonly used to determine the level of heat stress in dairy cows. Animals are experiencing heat stress at a THI of 72 and greater [32]. Gaafar et al. (2011) [33] stated that animals in Egypt expose to heat stress during summer season. Management strategies are needed to minimize heat stress and attain optimal animal performance.

| Item | Winter season | Summer season | Change | p-value |
|---|---|---|---|---|
| Ambient temperature °C | $15.38 \pm 0.90^{b}$ | $27.68 \pm 0.57^{a}$ | + 12.30 | 0.000 |
| Relative humidity % | $57.67 \pm 0.88^{b}$ | $79.67 \pm 0.88^{a}$ | + 22.00 | 0.000 |
| Temperature humidity index (THI) | $59.26 \pm 1.23^{b}$ | $79.13 \pm 0.88^{a}$ | + 19.87 | 0.000 |

**Table 4:** Ambient temperature, relative humidity and temperature humidity index for winter and summer seasons.

### 3.2 Nutrients digestibility and feeding value

Nutrients digestibility and feeding values of winter and summer rations are shown in Table (4). Digestibility coefficients of all nutrients (DM, OM, CP, CF, EE and NFE) and feeding values (TDN and DCP) reduced significantly (P<0.05) for summer ration compared to winter ration. The high digestibility coefficients of all nutrients and subsequently TDN and DCP values in the rations of suckling calves might be a result of the higher intake of whole milk and starter (Table, 1) and the higher contents of EE and CP of tested feedstuffs (Table, 2). These result are in agreement with the findings of Yadav et al. (2016) [34] stated that nutrients digestibility was affected by intensity of heat stress. Several studies have reported that higher ambient temperatures reduce the digestibility of nutrients in poultry which may be due to reduced activity of trypsin, chymotrypsin, and amylase [35]. Jafar and others (2004) found that the digestion coefficients for DM, OM, CP, EE, NFE and thus TDN and DCP values by lactation were significantly higher (P <

0.05) for winter feeding than summer feeding. Some contradictory results were available to re-estimate the reduced digestibility of cattle under HS conditions (32.2 °C environment) [36].

This decrease can be explained by some factors, such as dilution of rumen contents caused by increased water intake [37], and decreased rumen and intestinal absorption of nutrients due to reduced blood flow [38]. Furthermore, Bernabucci et al. (1999) [39] suggested that these changes in digestibility were not only due to passage rate and DMI but also due to other factors mentioned previously, which may serve as an adaptive response of the GI tract with HS.

| **Items** | **Winter ration** | **Summer ration** | **Change** | **p-value** |
|---|---|---|---|---|
| **Digestibility coefficients %** | | | | |
| DM | 71.81 ± o.83$^{a}$ | 68.60 ± 0.79$^{b}$ | -3.21 | 0.049 |
| OM | 73.61 ± 0.85$^{a}$ | 70.30 ± 0.81$^{b}$ | -3.31 | 0.048 |
| CP | 71.50 ± 0.83$^{a}$ | 67.35 ± 0.78$^{b}$ | -4.15 | 0.032 |
| CF | 59.250.68$^{a}$ | 56.40 ± 0.65$^{b}$ | -2.85 | 0.039 |
| EE | 76.30 ± 0.88$^{a}$ | 73.90 ± 0.85$^{b}$ | -2.40 | 0.043 |
| NFE | 76.30 ± 0.87$^{a}$ | 72.60 ± 0.84$^{b}$ | -3.70 | 0.48 |
| **Feeding values %** | | | | |
| TDN | 77.05 ± 0.60$^{a}$ | 74.00 ± 0.57$^{b}$ | -3.05 | 0.021 |
| DCP | 13.92 ± 0.16$^{a}$ | 12.72 ± 0.15$^{b}$ | -1.20 | 0.015 |

a and b: Values in the same row with different superscripts differ significantly (P<0.05).

**Table 5:** Nutrients digestibility and feeding values of winter and summer rations.

### 3.3 Rumen fermentation activity

Rumen fermentation activity of suckling Friesian calves during winter and summer seasons are shown in Table (5). The pH value and ammonia nitrogen concentration were higher significantly (P<0.05) for summer than winter season, However, total VFA concentration was higher significantly (P<0.05) for winter than summer season. Besides, rumen microbiota and fermentation of heifers would change during HS.

During HS, the community of ruminal microbiota is significantly restructured due to the alteration in the composition and volume of feed, leading to the change of the ruminal fermentation product [40, 41]. Uyeno et al (2010) [42] showed that the relative abundance of the Clostridium coccoides-Eubacterium rectale, a group of butter-producing bacteria [43], and the genus Streptococcus while the genus Fibrobacter, a representative of the acetate-producing bacteria increased in Calves under HS conditions (33 °C environment) [44]., decreased in heifers under HS conditions (33 °C environment). Heifers under HS conditions (around 32 to 33 °C environment) had decreased amount of volatile fatty acids (VFAs), reduced amount and concentration of acetic acid and increased amount and concentration of butyric acid [45, 46].

These changes may contribute to the poor growth performance of growing livestock because VFAs serve as their primary energy source and the amount they can use is reduced [45]. Heat stress reduces total volatile fatty acid (VFA) production with individual variation and also results in increase in ruminal pH [47]. Gao et al. (2017) [48] found that rumen liquor ammonia nitrogen concentration was or tended to be increased in heat stress cows.

### 3.4 Blood serum biochemical

Blood serum biochemical of suckling Friesian calves during winter and summer seasons are presented in Table (5). Concentrations of serum total protein, globulin and glucose were significantly ($P<0.05$) higher for winter season compared to summer season. Whereas, albumin concentration was nearly similar for winter and summer seasons. However, albumin to globulin ratio, concentrations of urea and creatinine and activity of AST and ALT activity were significantly ($P<0.05$) lower for winter season compared to summer season. Although, values blood biochemical presented in this study fall within the normal ranges in the blood serum of cattle as stated by UCDAVIS (2001) [49].

Decreased gluconeogenesis and glycogenolysis were observed in cows during heat stress [50]. Vijayakumar et al. (2011) [51] who found a significantly higher blood glucose level in buffalo heifers treated with sprinklers and fans for reduction of summer stress. The serum SGOT and SGPT activity was higher in hear stress grouped calves because of higher temperature inside the shade material, which increases the serum SGOT and SGPT activity in order to compensate for the other negative effects of thermal stress on the physiological and biochemical homeostatic mechanisms [52]. Srikandakumar et al. (2003) [53] and Brijesh (2012) [54] reported an increase in the serum SGOT and SGPT activity during thermal stress under different situations. Dar et al. (2019) [55] reported significantly lower serum protein levels during the summer season in >1 year of age than in the winter season in Badri cattle. The higher serum creatine concentration during dry and short rainy seasons might be because of excess muscular catabolism for energy supply as voluntary feed intake is reduced due to these seasons [56]. A higher concentration of creatine during summer stress was also reported by Dar et al. (2019) [55]. A higher blood urea concentration was reported during summer compared to winter in >1 year age of Badri cattle [55]. Our results were also in agreement with Rasouli et al. (2004), who reported higher blood urea nitrogen during the summer season. This increase may be due to the utilization of amino acids for energy. The other reason may be due to protein mobilization from muscle tissue and stress-related cortisol elevation, which increases catabolism of body proteins [55]. Dar et al. (2019) stated serum total protein and globulin levels during winter season were significantly higher than summer season, where albumen concentration was unaffected by seasonal effects.

| Items | Winter season | Summer season | Change | p-value |
|---|---|---|---|---|
| **Rumen fermentation activity** | | | | |
| pH value | $6.28 \pm 0.07^{b}$ | $6.66 \pm 0.08^{a}$ | +0.38 | 0.023 |
| TVFA's (meq/ 100 ml) | $9.81 \pm 0.11^{a}$ | $9.20 \pm 0.11^{b}$ | -0.61 | 0.017 |
| $NH_3$-N (mg/100 ml) | $8.19 \pm 0.09^{b}$ | $8.97 \pm 0.10^{a}$ | +0.78 | 0.015 |
| **Blood plasma biochemical** | | | | |
| Total protein (g /dl) | $7.45 \pm 0.09^{a}$ | $7.10 \pm 0.08^{b}$ | +0.35 | 0.042 |
| Albumin (g/dl) | $3.45 \pm 0.04$ | $3.60 \pm 0.04$ | -0.15 | 0.060 |
| Globulin (g/dl) | $4.00 \pm 0.05^{a}$ | $3.50 \pm 0.04^{b}$ | +0.50 | 0.010 |
| Albumin: globulin ratio | $0.86 \pm 0.01^{b}$ | $1.03 \pm 0.01^{a}$ | -0.17 | 0.005 |
| Glucose (mg/dl) | $68.50 \pm 0.79^{a}$ | $61.60 \pm 0.71^{b}$ | -6.90 | 0.013 |
| Urea (mg/dl) | $26.80 \pm 0.31^{b}$ | $31.70 \pm 0.37^{a}$ | +4.90 | 0.011 |
| Creatinine (mg/dl) | $1.18 \pm 0.01^{b}$ | $1.65 \pm 0.02^{a}$ | +0.47 | 0.003 |
| AST (IU/L) | $41.90 \pm 0.48^{b}$ | $67.60 \pm 0.78^{a}$ | +25.70 | 0.006 |
| ALT (IU/L) | $22.60 \pm 0.26^{b}$ | $34.70 \pm 0.40^{a}$ | +12.10 | 0.007 |

a and b: Values in the same row with different superscripts differ significantly ($P<0.05$).

**Table 6:** Rumen fermentation activity and blood plasma biochemical of suckling Friesian calves during winter and summer seasons.

### 3.5 Blood hematological parameters

Mean values of hematological parameters are given in Table (6). Mean values of hemoglobin (HGB) concentration and count of white blood cells (WBC) and red blood cells (RBC) were declined significantly ($P<0.05$) with summer season compared to winter season due to heat stress. However, haematocrit percentage (HCT), mean cellular volume (MCV), mean cellular haemoglobin (MCH) and mean cellular haemoglobin concentration (MCHC), were raised significantly ($P<0.05$) for summer season than those of winter season due to heat stress. The lower WBC counts noticed in the dry season might be due to the body system's response to stress stimuli compared to the long rainy season. During the study periods, regardless of the seasons, the calves were given similar routine health management such as deworming and continuous monitoring of health status. Moreover, they were given fodder with good nutritional content as well as shade from intense sunlight. This indicates that further improvement strategies for calves need to be developed to meet the expected severe climate change in the future. Likewise, Mirzadeh et al. (2010) [57] study and reported lower WBC in summer compared to spring, autumn and winter in all age groups of Iranian cattle which is in line with our results.

The average value of total red blood cells was significantly lower in the long rainy season than in the short and dry seasons. Furthermore, Naik et al., (2013) [58]. A similar study found significantly higher RBC values in summer than in winter and monsoon in different age groups in Bunganur cattle. Aengwanich et al. (2011) [59] found no significant changes in RBCs between summer, rain and winter seasons in beef cattle.

The higher number of RBC in dry and short rainy seasons might be associated with relatively higher stress in the body requiring more oxygen transport throughout the body. Furthermore, the lower RBC during the long rainy season could be due to increased water intake through the lush grasses that were available in that season [60] or high RH observed in the long rainy as compared to other seasons would have compromised evaporative heat loss mechanisms resulting in HS and, therefore, animals would have ingested more water and subsequent hemodilution and hence decreased RBC [61]. The lower HGB observed in the dry and long rainy seasons may be because of smaller RBC counts observed in these seasons. The lower MCV and MCH in the short rainy season and MCHC in the dry season in this study may be due to the lower amount of HGB present per RBC. However, the effect of season was not significantly affected by HCT (P > 0.05). Similar results were reported by Aengwanich et al. (2011) [59] who stated that the season did not affect the hematological parameters of calves in the northeastern part of Thailand. In contrast to this finding, a significant decrease in HCT was observed in summer compared to winter in all livestock age groups [57]. Despite the higher critical values of AT, RH and THI in all three seasons and the absence of variance in HCT again indicates the adaptive capacity of Fujira cattle calves to their current productive environment.

| **Items** | **Winter season** | **Summer season** | **Change** | **p-value** |
|---|---|---|---|---|
| WBC's (×$10^3$/µl) | 11.78 ± 0.25a | 9.68 ± 0.16b | -2.10 | 0.015 |
| RBC's (×$10^6$/µl) | 8.40 ± 0.05a | 6.93 ± 0.22b | -1.47 | 0.017 |
| HGB (g/dl) | 11.12 ± 0.22a | 9.92 ± 0.20b | -1.20 | 0.022 |
| HCT (%) | 32.33 ± 0.49b | 35.41 ± 0.88a | +3.08 | 0.025 |
| MCV (fL) | 33.85 ± 0.64Bb | 38.86 ± 6.32a | +5.01 | 0.021 |
| MCH (pg) | 13.36 ± 0.30b | 18.69 ± 1.35 a | +5.33 | 0.012 |
| MCHC (g/dl) | 28.82 ± 0.90b | 33.47 ± 1.35a | +4.65 | 0.019 |

a and b: Values in the same row with different superscripts differ significantly (P<0.05).

**Table 7:** Blood hematology parameters of suckling Friesian calves during winter and summer seasons.

### 3.6 Feed intake

Feed intake: Table (7) shows the amount of feed that is eaten by feeding Friesian calves during the winter and summer seasons. Intake of DM was nearly similar for winter and summer feeding being 1.46 and 1.43 kg/head/day, respectively. Whereas, the intake of

TDN, CP and DCP were higher significantly (P<0.05) for winter season than those of summer season. These results are in agreement with those obtained by Rauba et al. (2019) [62] reported that calves born in summer have less dry matter than those born in winter. Prusik et al (2009) showed that calves under heat stress conditions (74.8 of THI) had reduced intake of starters compared to those raised under moderate conditions (59.7 of THI). Colditz and Killaway (1972) [63] showed that calves raised under heat stress conditions (38 °C environ-ment) had reduced feed intake compared to those kept under cold ambient conditions (17 °C environment). Similarly, Baccari et al. (1983) [64] also reported lower feed consumption for Holstein calves under HS conditions (32.5–34 °C environment) compared to cooler conditions (18–20 °C environment).

Furthermore, Nonaka et al. (2008) [45] found that daily dry matter intake of prepubertal Holstein calves in a 33 °C environment was reduced by 9% compared to that raised in a 28 °C environment.

| Items | Winter season | Summer season | Change | p-value |
|---|---|---|---|---|
| **Total intake (as fed)** | | | | |
| Whole milk (kg) | 326.63 | 343.72 | +17.09 | - |
| Calf starter (kg) | 88.40 | 93.02 | +4.62 | - |
| Fresh berseem (kg) | 222.07 | - | - | - |
| Berseem hay (kg) | - | 37.44 | - | - |
| Total | 637.10 | 474.18 | - | - |
| **Daily intake (as DM)** | | | | |
| DM (kg/day) | 1.46 ± 0.02 | 1.43 ± 0.02 | -0.02 | 0.329 |
| TDN (kg/day) | $1.12 \pm 0.01^{a}$ | $1.07 \pm 0.01^{b}$ | -0.05 | 0.033 |
| CP (g/day) | $283.47 \pm 3.27^{a.}$ | $268.23 \pm 3.10^{b}$ | -15.24 | 0.028 |
| DCP (g/day) | $202.68 \pm 2.34^{a}$ | $180.65 \pm 2.09^{b}$ | -22.03 | 0.012 |

a and b: Values in the same row with different superscripts differ significantly (P<0.05).

**Table 8:** Feed intake by suckling Friesian calves during winter and summer seasons.

### 3.7 Growth performance

Growth performance of suckling Friesian calves during winter and summer seasons are presented in Table (8). Suckling period was longer significantly (P<0.05) for summer season than that for winter season. Calves used in this experiment were chosen to be approximately the same in birth weight for the winter and summer seasons. Whereas, weaning weight, total weight gain and average daily gain were higher significantly (P<0.05) for winter season in comparison with summer season. However, mortality rate was higher significantly (P<0.05) in summer season compared to winter season due to heat stress. Heat stress exerts a negative effect on growth performance of calves and heifers. It has been reported that dairy calves born in summer tend to have lower average daily gain (ADG) than those born in winter [65]. Colditz and Killaway (1972) [63] showed that calves raised in HS condition (38°C environment) had reduced feed intake and ADG compared to those kept under cool ambient conditions (17°C environment). Similarly, Baccari et al. (1983) [64] also reported lower feed consumption, ADG and feeding efficiency of Holstein calves under HS conditions (32.5 to 34 °C environment) compared to cooler conditions (18 to 20 °C environment). Furthermore, Nonaka et al. (2008) [45] found that the daily dry matter intake and ADG of prepubertal Holstein calves in the 33 °C environment decreased by 9% and 22%, respectively, compared to those raised in the 28 °C environment, while the water intake increased by 23% due to Increased evaporative water loss, such as sweating. In addition to these findings, a study determined the adverse effect of HS on the yield of dairy substitutes less than 2 years of age. In this study, responses of dairy substitutes younger than 2 years of age to HS, such as decreased DMI losses, and increased monthly mortality [66].

| **Items** | **Winter season** | **Summer season** | **Change** | **p-value** |
|---|---|---|---|---|
| Number of calves | 20 | 20 | - | - |
| Suckling period (day) | $109.57 \pm 1.24^{b}$ | $113.44 \pm 1.31^{a}$ | +3.87 | 0.035 |
| Birth weight (kg) | 30.65 ± 0.37 | 31.90 ± 0.37 | +1.25 | 0.655 |
| Weaning weight (kg) | $96.70 \pm 1.12^{a}$ | $93.13 \pm 1.06^{b}$ | -3.57 | 0.041 |
| Total weight gain (kg) | $66.05 \pm 0.75^{a}$ | $61.23 \pm 0.70^{b}$ | -4.82 | 0.019 |
| Average daily gain (g) | $602.81 \pm 6.97^{a}$ | $539.76 \pm 6.13^{b}$ | -63.05 | 0.011 |
| Mortality rate % | $10.00 \pm 0.12^{b}$ | $15.00 \pm 0.17^{a}$ | +10.00 | 0.005 |

a and b: Values in the same row with different superscripts differ significantly (P<0.05).

**Table 9:** Growth performance of suckling Friesian calves during winter and summer seasons.

### 3.8 Feed conversion ratio

Feed conversion of suckling Friesian calves during winter and summer seasons are illustrated in Table (9). Heat stress reduced feed conversion during summer season, which the amounts of DM, TDN, CP and DCP per kg weight gain were higher significantly (P<0.05) for summer season compared to winter season. These results might be due to reduce average daily gain during summer season due to heat stress. These results are in agreement with the finding of Baccari et al. (1983) [64] reported lower feed efficiency of Holstein heifers under heat stress conditions (32.5 to 34 °C environment) compared with cooler conditions (18 to 20 °C environment). Heat stress increases energy maintenance requirements which lead to decreased feed efficiency [67]. Feed efficiency decreases during heat stress [68]. During hot weather reduced efficiency of feed conversion [69]. Gaafar et al. (2004) [70] found that the amounts of DM, TDN and DCP required per one kg weight gain were higher during summer than winter season.

### 3.9 Economic efficiency

Economic efficiency of suckling Friesian calves during winter and summer seasons are shown in Table (9). Feed cost was nearly similar for winter and summer seasons, whereas feed cost per kg weight gain was higher significantly (P<0.05) for summer season than winter season due to lower ADG because heat stress. However, output of ADG, net revenue and economic efficiency were higher significantly (P<0.05) for winter season than those of summer season. These results might be due to the reduction of ADG during summer season due to heat stress. Economic efficiency of winter season increased by 10% compared to summer season. The economic losses in consideration were: 1) decreased performance (feed intake, growth, milk, eggs, 2) increased mortality, 3) decreased reproduction [66]. Livestock industries incurred economic losses due to raising animals Farm in places and seasons where temperature conditions venture outside of thermal comfort zones [71, 72].

With only minimal heat abatement intensity (natural ventilation), economic losses would be large in areas with high temperatures and humidity that lasts for several months each year [73]. It is likely that climate change will have a considerable impact on the economic viability of animal agriculture [74].

| Items | Winter season | Summer season | Change | p-value |
|---|---|---|---|---|
| **Feed conversion ratio** | | | | |
| DM (kg/kg weight gain) | $2.41 \pm 0.04^b$ | $2.69 \pm 0.03^a$ | +0.28 | 0.013 |
| TDN (kg/kg weight gain) | $1.86 \pm 0.02^b$ | $2.01 \pm 0.02^a$ | +0.15 | 0.010 |
| CP (g/kg weight gain) | $469.76 \pm 5.42^b$ | $505.19 \pm 5.83^a$ | +35.43 | 0.011 |
| DCP (g/kg weight gain) | 335.88 ± 3.88 | 340.25 ± 3.93 | +4.37 | 0.473 |
| **Economic efficency** | | | | |
| Feed cost (LE/day) | 23.93 ± 0.28 | 23.68 ± 0.27 | -0.25 | 0.561 |
| Feed cost (LE/kg gain) | $39.69 \pm 0.46^b$ | $43.87 \pm 0.51^a$ | +4.18 | 0.014 |
| Output of weight gain (LE/day)) | $42.20 \pm 0.49^a$ | $37.78 \pm 0.43^b$ | -4.42 | 0.011 |
| Net revenue (LE/day) | $18.27 \pm 0.21^a$ | $14.10 \pm .0.16^b$ | -4.17 | 0.007 |
| Economic efficiency[1] | $1.76 \pm 0.02^a$ | $1.60 \pm 0.02^b$ | -0.16 | 0.012 |
| Economic efficiency[2] | $76.36 \pm 0.88^a$ | $59.56 \pm 0.66^b$ | -16.80 | 0.006 |

a and b: Values in the same row with different superscripts differ significantly (P<0.05).

Economic efficiency[1] = price of weight gain / feed cost.

Economic efficiency[2] = net revenue * 100 / feed cost.

**Table 10:** Feed conversion ratio and economic efficiency of suckling Friesian calves during winter and summer seasons.

(P<0.05) higher during summer season as compared to winter season; these results indicated that the continuous movements of the loose animals especially under hot weather may increase the core temperature, which resulted in increasing the physiological parameters. El-Nouty (1996) [75] found that thermal stress causes a rise in core temperature and activate heat loss mechanism via panting and sweating. The respiration rate was found to be the most sensitive physiological response to the environmental conditions than other physiological responses. Kundu and Bhatnagar (1980) [76] reported that the RR plays an important role in thermoregulatory mechanism amongst all the physiological reactions and body temperature comes next. The values of rectal temperature (RT), skin temperature (ST) and respiration rate (RR) showed high correlations with air temperatures [5-7]. Increased RT is considered to be a good indicator of heat stress in animals [53]. Significantly increased RT with increase in THI during summer season indicates that the animals were in heat stressed condition [77]. During summer season, higher RR may be due to adaptive mechanism of heat loss [78] and increased PR and ST may be due to vasodilatation of skin capillary bed and consequently increase in blood flow to body surface areas to facilitate heat dissipation [79].

### 3.10 Physiological parameters

The effect of heat stress on rectal temperature (RT), skin temperature (ST), respiration rate (RR) and pulse rate (PR) are presented in Table (10). All physiological parameters such as RT, ST, RR and PR were significantly 2014). Respiration rate, pulse rate, rectal temperature, milk yield and leptin also increased during summer season [80].

| Items | Winter season | Summer season | Change | p-value |
|---|---|---|---|---|
| Rectal temperature ($^{o}$C) | 37.8 ± 0.44 | 38.3 ± 0.44 | +0.50 | 0.466 |
| Skin temperature ($^{o}$C) | 29.2 ± 0.34$^{b}$ | 34.5 ± 0.40$^{a}$ | +5.30 | 0.021 |
| Respiration rate (Breaths/min) | 23 ± 0.27$^{b}$ | 28 ± 0.32$^{a}$ | +5.00 | 0.014 |
| Pulse rate (beats/min) | 61 ± 0.70$^{b}$ | 68 ± 0.78$^{a}$ | +7.00 | 0.013 |

a and b: Values in the same row with different superscripts differ significantly (P<0.05).

**Table 11:** Physiological parameters of suckling Friesian calves during winter and summer seasons.

## 4. Conclusion

Based on the results of this work, we concluded that suckling calves are exposed to heat stress during summer season, hence the compromised growth performance, reduced feed digestibility, production of rumen fermentation, feed conversion and economic efficiency.

Also, heat stress caused undesirable chan-ge in blood biochemical and hematological changes and some physiological parameters, Productive benefits should be taken into consideration when developing strategies to ameliorate heat stress.

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