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Effect of barn ventilation on blood gas status and some physiological traits of dairy cows

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Abstract: *Twenty Holstein friesian and Brown swiss cows were used to investigate the effect of insufficient inbarn ventilation on blood gas status and some physiological traits of the cows. Animals were kept in mechanically ventilated barn in stall barn (I); and the ventilation funnels of the barn were closed to simulate traditional habits of the region's breeders (II); then cows were transfered open-shed barn (III). For each experimental of 10 days period, respiration and pulse rates and blood gas of animals were measured. Temperature, relative humidity,* CO_2 *and* NH_3 *concentrations were recorded in each barns. In mechanically ventilated barn, climatic and atmospheric gas was in normal ranges for the cows but in unventilated barn they were at the upper levels. In experiment II, blood pH was decreased without* pCO_2 *change. The highest blood* pO_2 *and* HCO_3^- *levels were found when the animals were kept in open-shed barn (III). Measured parameters were not influenced by breed of the cows. Blood pH,* pO_2, HCO_3^-*, respiration and pulse rates of the cows were significantly affected by barn types (p<0.05 and p<0.01). Respiration and pulse rates were higher in inadequate (II) barn conditions than those of open-shed. Higher levels of gases, especially carbon dioxide, in the unventilated barn significantly influenced biological parameters of cows. It is concluded that poor ventilation caused considerable changes in physiologic parameters of the cows and can potentially affect animal health and production.*

Key words: *Dairy cows, Barn gas, Blood gas, Respiration rates, Pulse rates*
PDF of full length paper is available with author ***(*nilcoban@gmail.com)***

Introduction

It is very important to optimize physical and climatic environmental conditions to keep health, welfare and production of the livestock. Especially, athmospheric factors [temperature, relative humidity, concentrations of ammonia (NH_3), carbondioxide (CO_2)] have very important effects on productivity and health of the animals (James *et al.*, 1993; Tilak *et al.*, 2007).

The reaction of cattle to different physical environment can be determined with the change amount of respiration and pulse rate (per minute) and some biochemical parameters of the blood. Blood traits, such as blood gas levels have special importance and are commonly used as determiners for respiration diseases and acid-base equilibrium disorders (Dutta *et al.*, 2005). Blood gases are affected by the age, sex, breed type of the cattle, feed regime and barn conditions (Kelly, 1984).

In Eastern Anatolian region of Turkey, harsh and cold climate conditions reign about 6 months of a year. Temperature drops around (-20°C to -30°C) and it snows too much. Because of cold and snow, cattle producers have a misconception that cattle have to be housed in hot barn to obtain maximum yield. Therefore, all air inlets and outlets are closed tightly to raise the temperature of the barn (Yanar *et al.*, 2000). As a result, temperatures, relative humidity, hazardous gas such as carbondioxide, ammonia increase considerably.

There is scarce scientific study on blood gas of the animals kept in various environmental conditions (Thielscher *et al.*, 1995). In this study, Holstein friesian and Brown swiss cows were kept in various barns with various temperature, relative humidity and environmental gas levels. It is aimed to determine the possible negative effects of the farmers' tradional habit (insufficient inbarn ventilation) on blood gas status and some physiological traits of dairy cattles.

Materials and Methods

Ten cows for each breed type, Holstein griesian and Brown swiss, in the stage of 2-4th month of the lactation periods, were used in this research in November, 2005. Cows were balanced in terms of parity (4 partrution), body condition score (Score 4) and milk production (2000-2500 kg). They were in individual stalls in Dairy Research Unit barns of Ataturk University. In the first 10 days of the research (I); barns were ventilated naturally and mechanically; respiration and pulse rates were determined and the blood samples were collected twice, with five day intervals. For the second period (II); the funnels, windows and doors of the barn were closed, to get an increase of the levels of temperature, environmental gas and relative humidity, for ten days; this period simulated common application of the region's breeders. In the middle and at the last of this period, biochemical and physiological measures were repeated. At the third period (III), cows were transfered to an open-shed barn in the same unit. In open-shed barn conditions, they were kept for ten days and blood gas levels and physiological parameters were determined twice, with five day intervals (Sagsoz *et al*., 2003).

The cows were fed concentrate feed (1.5 kg/head) before the milking in the morning and evening. Wet sugar beet pulp (8 kg/ head) and dry hay and water were offered *ad.lib.* daily to the animals.

Carbondioxide (CO_2) and ammonia (NH_3) levels of the barn's athmosphere were measured by using a carbondioxide analyser (infra red) and the dragger device (electrochemistry), three times in a day. The temperature and relative humidity were recorded continously by using a thermohygrograph. Respiration and pulse rates were determined by using a stethescope, three times in a day. For daily value for temperature, relative humidity and environmental gas for barns, mean value of the measures were used.

For each research period, blood samples, collected from *Vena jugularis*, held in an ice bath and sent immediately to the laboratory within 30 minutes. Blood pH, pO_2, pCO_2 (p = pressure) and HCO_3^- were measured directly by using Bayer-Rapid Lab 865 equipment in Faculty of Medicine of Ataturk University.

Blood samples (20:00-20:30 pm) and physiological traits (morning: 08:00-09:00; midday: 12:00-13:00 and evening: 19:00-20:00) were determined on fifth and tenth days of each period and the averages were calculated Slanina *et al*. (1991). Because of that the blood and physiological traits were measured on same animals for three periods, twice for each period; barn effect was thought to be dependent (within effect), breed effect was independent group (between effect), so repeated measures variance analysis was performed with two factorial interaction model. For multiple comparisons, Bonferroni Multiple comparison test was used and some correlations were calculated (SPSS version 9.0, 1997).

Results and Discussion

Mean values for climatic and atmospheric measures in three barn conditions are shown in Table 1. Optimal temperature and relative humidity levels are adviced to be 10-15^{o}C and 60-70% in stall cattle barns (Alpan, 1993). In the stall barns, upper levels of CO_2 and NH_3 must be 3500 ppm (%0.5) and 30 ppm, respectively for maintaning the health and welfare of the livestock (Emay and Dixon, 1986). In mechanically ventilated barn (I), temperature, relative humidity levels and gas concentrations were close to optimum standards. In unventilated barn, the concentration of carbon dioxide and ammonia was high. In the barns, where this research performed, floor was concentrate constructioned and urine and feces were being removed by lobourers. In the second period, removing processes were slowed down, to simulate breeders' habits of the region. But, the ceiling of the barn was made from wood and there were straw bales on the windows which works as a filter; so carbon dioxide and ammonia concentration had not increased too much, although ventilation and removing processes were impeded. The barns, made completely from concentrate constructions may have more difficulties when these processes are slowed down. Karademir *et al*. (2001), attracted attention to this problem in the barns of Kars region.

For three barn conditions, means for measured blood traits and statistical analysis results are shown in Table 2. There was no statistical difference between Brown swiss and Holstein friesian cows from blood pH and gas standpoint. Except for pCO_2, effect of barn type on blood gas was found to be significant statistically ($p< 0.01$). Highest levels for pH, pO_2 and HCO_3^- were obtained from the animals which were kept in open shed barn conditions.

pH value for venous blood was in the reported range of 7.34-7.44 (Slanina *et al*., 1991; Blood and Studdert, 1993; Karademir *et al*., 2001). In this experiment, blood pH levels of the cows were decreased to 7.373 in non ventilated barn (II) and increased to 7.432 units in open barn conditions (III). It is thought to be due to the compensation systems of the lungs and kidneys, to be able to cope with the disventilated conditions with a little trend to decrease. Hyperventilation would be stimulated to decrease excess pCO_2 and H^+ concentration, helping to return the pH to normal level.

The lowest pH and HCO_3^- levels were determined in the stall barn with inadequate condition (II). Breed-barn type interaction for blood pH level and pO_2 were found to be significant ($p=0.012$) and marginal significant ($p=0.065$) statistically. Both breeds' differed in reaction to different barn conditions from pH and pO_2 standpoint. pO_2 levels were increased when Holstein friesian cows were in open-shed and Brown swiss' were in unventilated barn conditions. There found a marginal significant ($p=0.065$) breed x barn interaction. It is thought that Brown swiss' had higher adaptation ability than Holsteins for unventilated inbarn conditions of the eastern region, similar to the earlier findings (Sagsoz *et al*., 2003).

Mean pO_2 value in blood, in first period was determined as 35.083 mm-Hg and close to the levels (27.41-33.35) reported by earlier researchers for cattle in same conditions (Karademir *et al*., 2001). An increase of blood pO_2 in the second period (to 46.190 mm-Hg) indicated the increased respiration functions (Savant and Amte, 1995), caused by the higher temperature, relative humidity and inbarn gas levels. After transfering cows into the open-shed barn (III. period), blood pO_2 maintained higher level (49.413 mm-Hg) was probably due to the result of the compensatory response by means of unventilated conditions in second period. Mortola *et al*. (1986) indicated that if hypoxia is extended for a long enough period, ventilation gradually rises again and persists beyond the period of hypoxia.

It is reported that venous blood pCO_2 range is between 38.28 mm-Hg and 49.72 mm-Hg (Karademir *et al*., 2001). Present levels for pCO_2 was close to upper limits but was not affected neither by breed nor barn types. It is thought that, the result was probably due to keeping cows in stall barns because of harsh winter conditions before and at the time of study, for a long time.

Table - 1: Means of atmospheric measures in the barns:

Barn types and/or conditions (*)	Temperature (°C)	Relative humidity (%)	CO_2 (% and ppm)	NH_3 (ppm)
Barn I	8.8	74	0.25 and 2500	6
Barn II	18.9	81	0.45 and 4500	21
Barn III	-7.0	54	0.01-0.10	0.3×10^{-6}

(*) I: Stall barn: with mechanical ventilation (routine ventilation)
II: Stall barn: ventilation funnels and windows were closed
III: Open-shed barn

Table - 2: Descriptives and statistical test results of blood pH and gas

Factors	n	pH $\bar{X} \pm S_{\bar{X}}$	pCO_2 (mm-Hg) $\bar{X} \pm S_{\bar{X}}$	pO_2 (mm-Hg) $\bar{X} \pm S_{\bar{X}}$	HCO_3^- (mmol/l) $\bar{X} \pm S_{\bar{X}}$
Breed		NS	NS	NS	NS
Holstein friesian	10	7.401± .006	47.785± .911	43.092±1.939	28.320±0.537
Brown swiss	10	7.405± .006	48.083± .911	44.032±1.939	29.118±0.537
Barn type		**	NS	**	**
I	20	7.403± .004^{b}	49.085±1.079	35.083±1.123^{c}	28.310±0.511^{b}
II	20	7.373± .005^{c}	47.323± .557	46.190± 2.314^{b}	26.965±0.389^{c}
III	20	7.432± .007^{a}	47.395± .848	49.413±2.513^{a}	30.883±0.530^{a}
Breed x Barn inter.		*	NS	+	NS
HF x I	10	7.402± .006^{b}	49.800±1.527	34.890±1.588^{e}	28.050± .765
HF x I	10	7.361± .008^{c}	46.845± .788	42.310±3.272^{d}	25.955± .551
HF x III	10	7.440± .010^{a}	46.710±1.109	52.075±3.554^{a}	30.955± .750
BS x I	10	7.405± .006^{b}	48.370±1.527	35.275±1.588^{e}	28.570± .765
BS x II	10	7.385± .008^{b}	48.800± .788	50.070±3.272^{b}	27.975± .551
BS x III	10	7.425± .010^{a}	48.080±1.199	46.750±3.554^{c}	30.810± .750

NS = Non significant, + = marginally significant (p=0.065), * = $p<0.05$, ** = $p<0.01$
Values having different letters are significantly different from each other

Table - 3: Descriptives and statistical test results of physiologic traits

Factors	n	Respiration rate (breaths/minute) $\bar{X} \pm S_{\bar{X}}$	Pulse rate (pulses/minute) $\bar{X} \pm S_{\bar{X}}$
Breed		NS	NS
Holstein friesian	10	30.2±1.0	63.0±1.1
Brown swiss	10	31.3±1.1	63.4±1.1
Barn types		**	**
I	20	27.2±1.1^{b}	61.7±1.0^{b}
II	20	38.3±1.0^{a}	66.3±1.5^{a}
III	20	26.7± .6^{b}	61.6± .7^{b}
Breed x Barn inter.		NS	**
HF x I	10	27.3±1.5	58.9±1.4^{bc}
HF x II	10	37.1±1.4	69.1±2.1^{a}
HF x III	10	26.4± .9	61.1± .9^{bc}
BS x I	10	27.2±1.6	64.5± 1.4^{b}
BS x II	10	39.6±1.5	63.6± 2.2^{b}
BS x III	10	27.0± .9	62.2± 1.4^{bc}

NS = Non significant, * = $p< 0.05$, ** = $p<0.01$
Values having different letters are significantly different from each other

The HCO_3^- levels were found to near the upper range, as compared to earlier findings (Carlson, 1996; Karademir *et al.*, 2001). HCO_3^- is reported to be 24-25 mmol/l in venous blood of cattle (Blood and Studdert, 1993). When compared with the first period of the experiment, in the second barn conditions, decrease of HCO_3^-, with the same trend of pH and pCO_2, indicated an effort by animals to prevent possible acidosis by hyperventilation and higher pulsation. In open-shed barn, blood of the cows had more HCO_3^-, this also showed that it also strongly affected by climatic and gas levels of the environment.

Respiration and pulse rates of the cows kept in three different conditions were measured and results are shown in Table 3. No difference was determined between two breeds for physiological traits. Interaction of breed x barn condition was found to be significant statistically for pulse rate.

Sagsoz *et al.* (2003) observed that Holstein friesian cows had 25.8 and 65.9; Brown swiss cows had 22.9 breaths/minute and 61.8 pulses/minute when kept in the stall barn, at 12°C temperature; 69% relative humidity, 2788 CO_2, 19 ppm NH_3 conditions, quite similar to barn (I) in this experiment. Sagsoz *et al.* (2003) also reported that when these levels were higher (21°C, 82%, CO_2= 5229 ppm and NH_3=34 ppm) respiration and pulse rates increased to 33.9 - 64.9 for Holstein friesian and 29.2-62.4 for Brown swiss cows. Holstein friesian cows were thought to be more sensitive to unventilated conditions than Brown swiss'.

A negative correlation between blood pCO_2 and pH (r^2= -0.499, p = 0.025); a positive correlation between HCO_3^- and pCO_2 (r^2 = 0.579, p = 0.007) and a negative correlation between HCO_3^- and pH (r^2 = -0.467, p = 0.042) were observed. It is thought that, when blood pH decreased, bicarbonate increased in plasma, to eleminate excess CO_2.

Findings showed that insufficient ventilation, especially high CO_2 ratio of inbarn athmosphere stimulated respiration and circulation fuctions of animals. Further long-time experiments (for example six months) are required to conclude the effect of insufficient ventilation on health and production parameters of cows. It is concluded that farmers of harsh and cold climates must reduce livestock density and supply fresh air in barns.

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