

MONITORING INDOOR CLIMATE IN A DAIRY BARN

Names of authors: Massabie P.

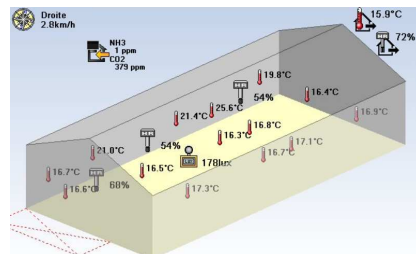
Institute/Organizacion/University: French Livestock Institute (IDELE)

1. Introduction

Dairy barn are usually under natural ventilation and air renewal rate is dependent of weather conditions. During summertime, heat stress is generally evaluated through THI (Thermal Humidity Index) calculated with outside temperature and humidity values. But depending on weather conditions, climate inside the barn could be quite different and heat stress could be underestimated. The objectives of this study was to determine how weather conditions and inside climate of the barn are linked. The effect of wind on CO2 and ammonia levels was also analyzed. Black globe temperature was also measured to determine if cows were exposed to radiant heat from walls or roof.

2. Materials and methods

An experimental farm with 80 lactating cows was equipped with ten temperature probes, four black globe temperature, three humidity sensors and one ammonia and one carbon dioxide probes. All the sensors were 2.5 m above the floor. This height was reported as adapted for dairy barn by Hempel and al. Weather parameters (temperature humidity, wind speed and direction) were also recorded. Recordings were made on a complete year with an interval of fifteen minutes. The stable was 60 m length and 17 m width. The stable was equipped with two row of cubicles with straw and the manure was removed with two scrapers. The barn was fully opened on the East side. THI was calculated and HLI (Heat Load Index) was estimated with air velocity extrapolated with wind speed.



3. Results

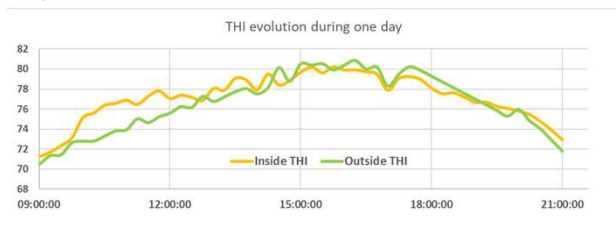
For one year, outside temperature ranged between -5.1 and 32.3 °C and was an average 12.7 °C +/- 6.96. Outside humidity ranged between 35 and 100 % and was an average 77.5% +/- 18.1

Inside temperature in the barn ranged between -4.6 and 34.2 °C and was an average 13.9 °C +/- 6.20. Inside humidity ranged between 24 and 86 % and was an average 66.6% +/- 11.2. All the ten temperature points' values were close in average with less than 0.5°C of difference. Relative humidity values were similar for the three point (difference was less than 1.5%).

Wind direction was mainly west (17%) and East Northeast (12%). Average wind speed was low (1.5 m/s) and was superior to 1 m/s only from East Southeast to West.



Black globe temperature was in average close to ambient temperature, but maximum values are 2.2 °C higher. During hottest day, sensor above cubicle near west side wall showed respectively an average value and a maximum 1.5°C and 2.9°C higher than temperature sensor.



Regarding one hot day, inside THI was higher than outside THI especially in the morning. This result showed that under certain weather conditions, THI calculated with weather station could underestimate real THI inside the dairy barn.

Number of days with an average THI > 72 and number of days with a minimum of 1 h averaging THI > 72 are quite different between outside and inside. These results indicate that, in studies which obtain climate data from a meteorological station, heat stress is often underestimated both in magnitude and duration.

4. Final Considerations

Those results showed that in opened dairy barns, wind could lower ammonia and dioxide carbon concentrations and maintain ambient temperature close to outside value. But when barns are partially closed, wind effect is reduced, and heat stress can occur before outside THI has reached critical level.

Difference between inside and outside temperature was in average 1.2 °C depending on season and wind direction. That difference is closed to value obtained by Elbez and al. or Schüller and al. in similar type of dairy barn. As reported by those authors, inside relative humidity was frequently higher than outside (+10.9%).

When wind came from opened side of the barn, inside and outside temperatures were similar. At the opposite, when wind was coming from closed side, inside temperature was in average 1°C above outside value



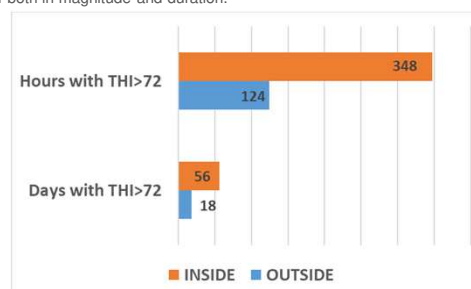
Wind speed (km/h)	Average inside temperature(°C)	Average outside temperature(°C)	Difference
0 (0)	12.8	11.9	0.9
0-5 (2.0)	15.6	15.4	0.2
5-10 (7.2)	14.7	14.8	-0.1
10-15 (12.2)	12.2	12.4	-0.2
15-20 (17.0)	10.7	10.7	0.0
>20 (22.3)	11.0	11.4	-0.4
			+0.1



Wind speed (km/h)	Average inside temperature(°C)	Average outside temperature(°C)	Difference
0 (0)	12.8	11.6	1.3
0-5 (2.2)	15.5	14.6	0.9
5-10 (7.3)	15.8	14.7	1.0
10-15 (12.4)	15.5	14.7	0.9
15-20 (17.4)	15.7	15.0	0.7
>20 (26.7)	15.6	15.0	0.6
			+1.1

Ammonia level was an average less than 1 ppm and the maximum value was 12 ppm. Carbon dioxide concentration was an average 469 ppm and the maximum value reached 1250 ppm. Both ammonia and carbon dioxide levels were minimum when wind was coming from north-east to south-east.

THI calculated from weather station has an average value of 54.8 and a maximum of 76.9. THI calculated with inside temperature and humidity was 56.9 in average and the maximum value was 80.6.



References

Erbez, M., Falta, D., Chládek, G., 2014. The relationships between temperature and humidity outside and inside the permanently open-sided cow's barn. Acta Univ. Agric. Silv. Mendelianae Brun. 58, 91–96.

Hempel, S., König, M., Menz, C., Janke, D., Amon, B., Banhazi, T.M., Estellés, F., Amon, T., 2018. Uncertainty in the measurement of indoor temperature and humidity in naturally ventilated dairy buildings as influenced by measurement technique and data variability. Biosystems Engineering 166, 58–75.

Schüller, L.K., Burfeind, O., Heuwieser, W., 2013. Short communication: Comparison of ambient temperature, relative humidity, and temperature-humidity index between on-farm measurements and official meteorological data. Journal of Dairy Science 96, 7731–7738.

Shock, D.A., LeBlanc, S.J., Leslie, K.E., Hand, K., Godkin, M.A., Coe, J.B., Kelton, D.F., 2016. Studying the relationship between on-farm environmental conditions and local meteorological station data during the summer. Journal of Dairy Science 99, 2169–2179.