

## Use of DS18B20 sensor to evaluate silage temperature

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**Introduction** As dairy farms expand, storing food in silage form is an increasingly used strategy due to its practicality and low-cost (Taylor et al., 2003). However, improper handling of silage can result in a considerable amount of silage exposed to air. This situation consequently increases losses due to the growth of deteriorating microorganisms (Borreani et al., 2018). Therefore, monitoring this process through sensors allows quick detection of small temperature variations so that the conservation process is more effective (Green et al., 2009). The objective of this study was to evaluate the accuracy of the DS18B20 sensor to measure the silage temperature during aerobic exposure.

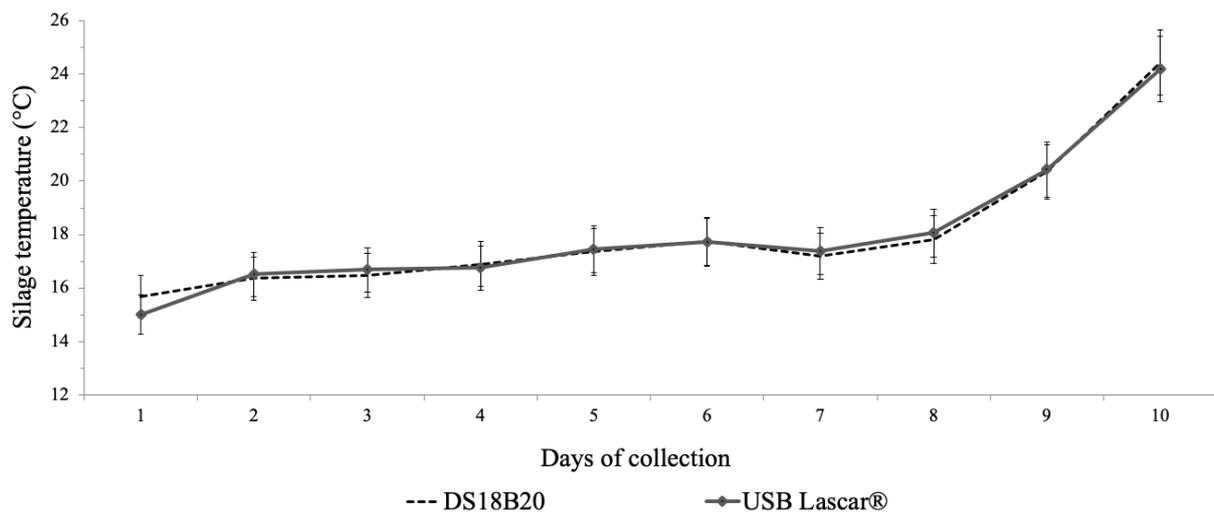
**Materials and Methods** The study was carried out at the Centro de Pesquisas em Forragicultura (CPFOR) located at the Canguiri Experimental Farm at the Federal University of Paraná. The accuracy of the DS18B20 in measuring silage temperature was evaluated during an aerobic stability experiment. Three experimental silos were opened after 400 days of storage and homogenized. After that, 28 kg of silage were allocated in seven experimental silos (4 kg/silo, n = 7) without compaction. To evaluate the silage temperature in each experimental silo, three data collection points (base, center and top) were defined. In these locations, we fixed a DS18B20 sensor and a lascar<sup>®</sup> USB data-logger, both configured to record the temperature every 5 minutes. The experimental silos were kept in controlled environment (24 °C ± 0.5) for 240 hours. The experimental design consisted of two treatments (DS18B20 sensor and USB lascar<sup>®</sup>), seven experimental units (experimental silos) and one dependent variable (silage temperature). The data were analyzed by Generalized Linear Models (GLM), with Gamma distribution and logarithmic bonding at a 95% level of confidence. All analyses (descriptive and confirmatory) were performed through the extension of Statistical Software R. Action Stat (Estatcamp, 2014).

**Results and Discussion** The silage temperature varied in a standardized way among experimental silos (Table 1). Temperature uniformity is important for the results to be compared with consistency and accuracy. In addition, like the concentration of organic acids, the temperature is also a parameter that affects the silage stability.

**Table 1** Mean values and standard error (SE) of the silage temperature registered by the sensors (DS18B20 and USB lascar®) in the experimental silos.

Exp. silos	DS18B20		USB lascar®	
	Average	SE	Average	SE
1	16.93	0.03	16.85	0.03
2	17.39	0.04	16.07	0.03
3	17.91	0.07	18.20	0.05
4	18.15	0.06	18.59	0.05
5	19.04	0.06	18.94	0.06
6	18.41	0.06	18.80	0.05
7	18.52	0.05	18.87	0.06

During silage aerobic exposure there is a heat production due to the action of deteriorating microorganisms. This heat production affects the internal temperature of silos, which is directly related to the quality of silage, as it interferes with the action of the microorganisms responsible for fermentation (Jobim et al., 2007). There was no difference ( $P = 0.993$ ) between silage temperature evaluated by DS18B20 and USB lascar® (Figure 1).



**Figure 1** Silage temperature variation among 10 days (240 hours) of evaluation.

In order to detect the early occurrence of silage decomposition and make food conservation increasingly efficient, there is a constant search for new low-cost technologies that can help researchers to measure physical variables related to silage quality. Based on this, the technology presented in this study allows the researchers to estimate dry matter losses based on the temperature variation.

**Conclusions** The DS18B20 sensor was efficient in measuring the silage temperature. This sensor is extremely versatile and can easily be applied as a tool to measure silage temperature in aerobic stability research.