Monitoring warming of silage with IoT based tool may help to predict silage quality

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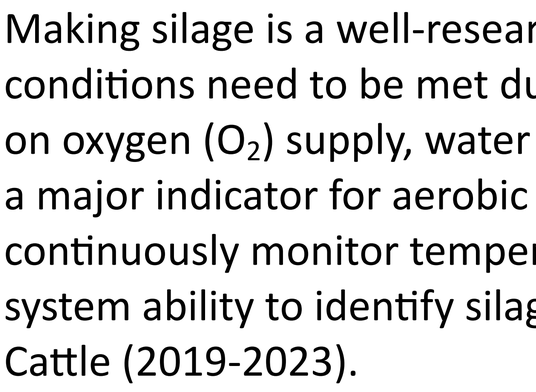
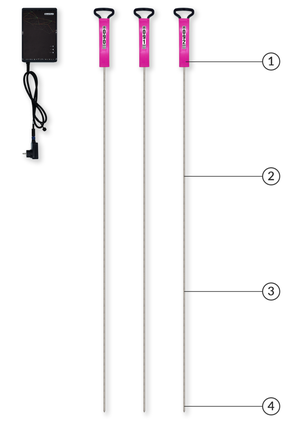
Introduction:

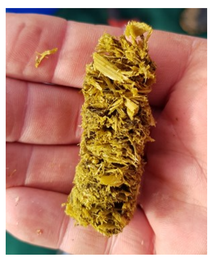
Making silage is a well-researched process with known quality parameters. To preserve the nutritional quality of the silage, specific conditions need to be met during the ensiling process. Aerobic fermentation is the primary cause of silage quality loss and depends on oxygen (O_2) supply, water soluble carbohydrates and water (McDonald et al. 2002) and produces excess heat in the process. Since a major indicator for aerobic fermentation in the silage is excessive temperature, we focused on creating a practical IoT based tool to continuously monitor temperatures within the silage. The main objective of this paper is to investigate the use of modern monitoring system ability to identify silage temperature changes and thus quality of silage. The study was a part of EIP-Agri project Good for Cattle (2019-2023).

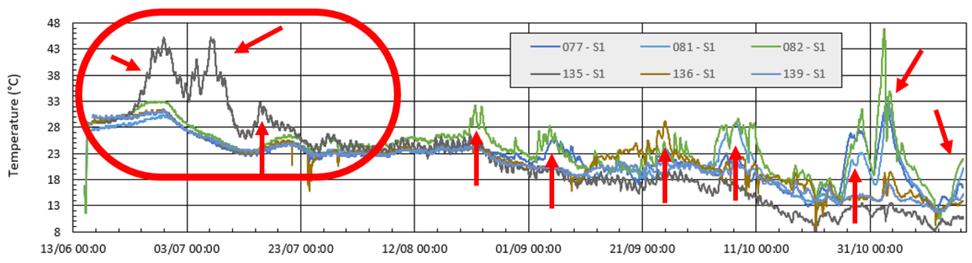
Method:

We measured temperatures within the silage continuously, and then correlated the temperature patterns to the nutritional values from samples taken in close locations to the sensors. The tool consists of an access point collecting data from sensor nodes and pushing data to an online user interface. Sensor nodes consist of three-meter-long rods, with four sensors at 1-meter intervals.
A total of 15 rods (three lines and five rows, with 3-meter separation) were installed in a bunker silo on a private dairy farm in the Jokioinen municipality in south-western Finland in 2020. The rods were were installed in a vertically drilled hole (250cm deep). The hole in the plastic was sealed to prevent airflow into the silage. Temperature monitoring started on June 15th immediately after the bunker was sealed and ended on November 25th. Samples representing vertical sensor locations of the silage were collected with a silage sampling drill and taken for quality analyses to Valio feed laboratory in Seinäjoki, Finland.









Sensor Depth: ± 50cm
Temperature excursions and anomalies
Evidence of aerobic spoiling

Results:

Continuous monitoring of the silage stack was succesful. Clear temperature excursions associated with aerobic fermentation were observed. Temperature development during the first weeks of storage correlated later on with the silage quality. Statistical analyses to find the correlation between silage quality and temperature history were run using JMP statistical software.

Conclusions:

The IoT based tool (Quanturi) used in this field study for temperature monitoring was useful. We conclude that this technology helps the farmer to know ensiling process better, improve harvesting practices, and even foresee undesirable quality before feed analysis. This helps in choosing optimal feeding strategies and in allocation of feeds for best results.

Figure 1. Number of days of incremental daily temperatures in bunker silo measured in the surface (-50cm), in the middle (-150cm) and in the bottom (-250cm) sections of silage. Each mean (±SE) represents 15 measuring points.

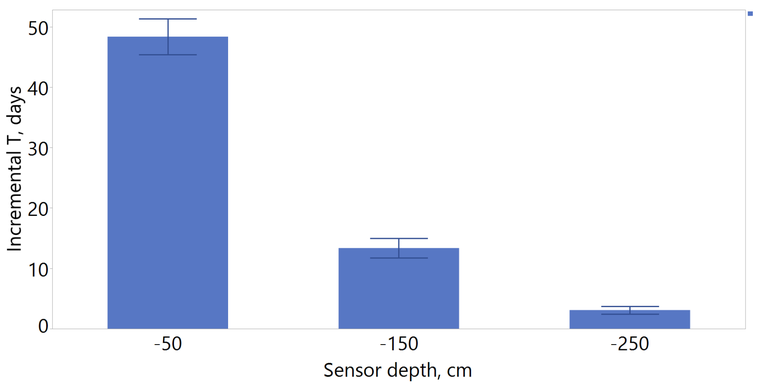


Figure 2. Relations between sugar content (g kg^{-1} DM) and number of days of incredimental daily temperatures in grass silage. Each dot represents one temperature sensor and feed sample taken near to the sensor.

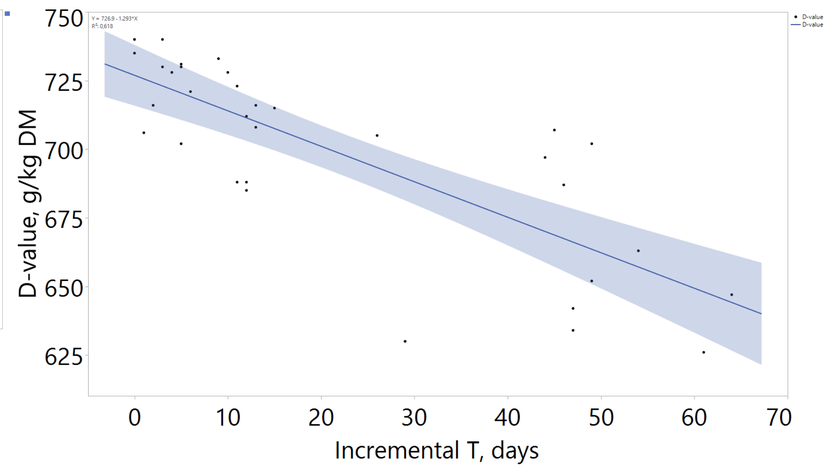
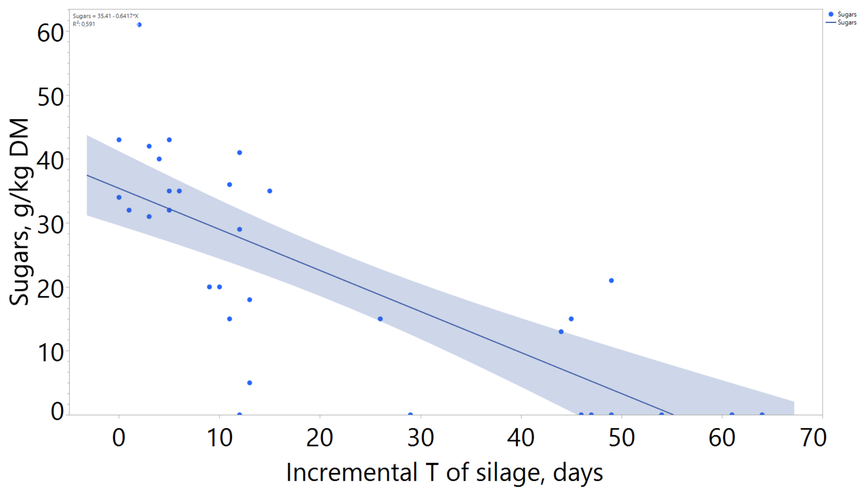


Figure 3. Relationship between D-value (g kg DM^{-1}) and number of days of incremental daily mean temperatures in grass silage after 5-month storage in bunker silo. Each dot represents one temperature sensor and feed sample taken



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