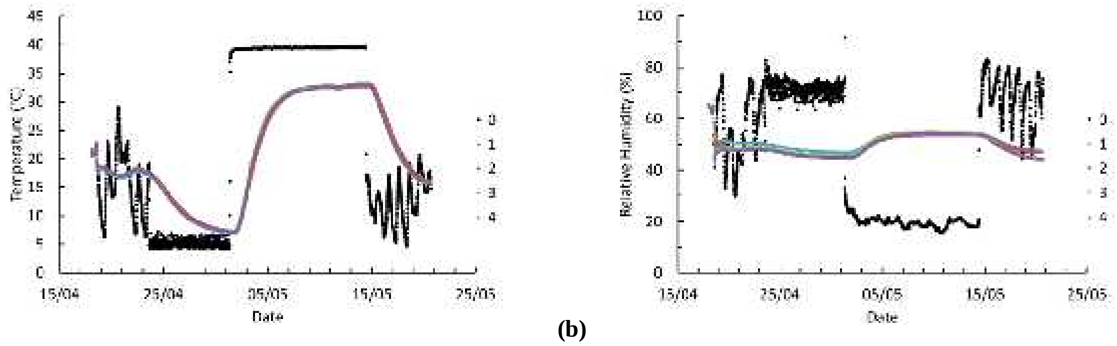
Sensing the temperature and humidity inside wool bales

R. Behrendt[A], *M. Majas*[B], *N. Linden* [A], *C. Beverly*[A] *and M. Knight* [A]

[A] Agriculture Victoria, Department of Jobs, Precincts and Regions, 915 Mt Napier Road, VIC 3300 Australia
[B] Digibale, Level 6, 68 Harrington Street, The Rocks, NSW 2000 Australia
[C] Email: ralph.behrendt@agriculture.vic.gov.au

Foot and mouth disease (FMD) is a contagious disease of cloven-hoofed animals and may survive from days to weeks in wool harvested from infected sheep (McColl *et al.* 1995). In an FMD outbreak, the World Organisation for Animal Health indicates that contaminated wool should be stored at 4 °C for four months, 18 °C for four weeks or 37 °C for eight days to eliminate the risk of FMD transmission through export. Wool is an insulating material with low thermal conductivity (Volf *et al.* 2015) and the core temperature (CT) of a wool bale will be more stable than the surface temperature (David and Nordon 1969). Sheep are shorn under varied climatic conditions, ranging from 40 °C in summer to less than 10 °C during winter. Wool bales are stored in shearing sheds and wool stores, where the temperature and relative humidity (RH) is often unregulated. Knowledge of the CT and RH of pressed wool bales in the supply chain may enable wool bales free from FMD to be identified and released for export.

An experiment was conducted using Bluetooth temperature and RH sensors (DIGIBALE™) to measure the CT and RH of wool bales. Four random wool bales were obtained from 2 lines of wool. Two bales of wool (P159) were from a 20.3 µm line with a vegetable matter content (VM) of 16.1 % and yield of 39.2 %. The other 2 wool bales (123 DW) were from a 20.0 µm line with a VM of 1.4 % and a yield of 51.5 %. Each wool bale was unpacked at ambient temperature and RH in a shearing shed and then pressed into a new wool pack with the sensors placed in the vertical centre of the bale at 20 kg weight intervals (~10cm depths). The wool bales were sat upright on their base for 5 days in a shearing shed (18 Apr to 23 Apr 2019) before transfer to a cool room at 4 °C (23 Apr to 1 May 2019) and then to an oven at 40 °C (1 May to 14 May 2019). On the 14 May 2019 the wool bales were returned to ambient conditions in the shearing shed until the 20 May 2019. The sensors were set to record CT and RH every 15 minutes with data downloaded via Bluetooth to the DIGIBALE™ MCM application (v2.3.2).



(a) **(b)**

Figure 1. The core temperature (a) and relative humidity (b) of 4 wool bales with sensors (1, 2, 3 and 4) placed at the centre of the bale, compared to a sensor(0) measuring ambient conditions.

The CT of all 4 wool bales took between 5 to 6 days to approach the ambient temperature and plateau under sustained cooling or heating (Figure 1a). The RH at the centre of the wool bale decreased under cooling and increased under heating (Figure 1b). The CT of bales with high VM (sensor 1 and 2) were about 1 °C cooler during the transition to warm temperatures. For example, the average daily CT on 4 May 2019 was 24.3°C for the bales with high VM compared to 25.4 °C in bales with lower VM and high dust (P = 0.036, LSD (5%) = 0.94). Straw, flax and hemp have low thermal conductivity and diffusivity (Volf *et al.* 2015) and it is possible that the VM is modifying the speed at which CT of a wool bale changes. However, the difference is small. Our results suggest that irrespective of the temperature at shearing and pressing, the wool bale will gradually change to reflect the ambient temperature of the storage environment after 1 week.

References

David HG and Nordon P (1969) *Textile Research Journal,* **39**(2),166-172.
McColl KA, Westbury HA, Kitching RP and Lewis VM (1995) *Australian Veterinary Journal*, **72**(8), 286-292.
Volf M, Diviš J, Havlík F (2015) *6th International Building Physics Conference, IBPC 2015. Energy Procedia* **78**, 1599 – 1604

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