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Microbial changes during the on-farm storage of canola (oilseed rape) straw bales and pellets

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ABSTRACT

The effect of on-farm storage on microbial growth on baled and pelletised *Brassica napus* (oilseed rape/canola) straw was investigated. Canola straw collected in 2008 and 2009 was stored baled in an open shed for 3, 4, 7, 10 and 20 months in 2008 and for 1 and 3 months in 2009. Pellets were produced from straw stored for 3, 7, and 10 months in 2008 and straw stored for 3 months in 2009, and stored for up to 48 weeks.

The moisture content (MC), water activity (a_w), bacterial and fungal colony-forming units (CFU), and carbon-to-nitrogen ratio (C:N) of canola straw bales and pellets were measured during storage. In addition, temporal environmental conditions (ambient temperature and relative humidity) and bale temperature were monitored. The moisture content showed a tendency to stabilise during storage, with an equilibrium moisture content of approximately 155 g kg^{-1} total weight for straw bales and 110 g kg^{-1} total weight for straw pellets. Consequently, the water activity of canola straw bales remained below 0.8 and that of pellets below 0.66 during storage, providing an explanation for relatively low microbial growth. The number of bacterial and fungal CFU present in the straw bales and pellets followed the trend of ambient relative humidity and no correlation was found with the C:N ratio of the biomass. Canola straw pellets were considered a superior combustion fuel to straw bales due to lower moisture content and less microbial deterioration during storage.

1. Introduction

In the United Kingdom (UK), the total area of canola (*Brassica napus*) harvested increased from 4020 km^2 in 2000 to 5720 km^2 in 2009 [1]. Currently there is no market for canola straw in the UK, and the majority is chopped and incorporated into the soil. Previous research has shown canola straw has a calorific value ranging between 16.9 MJ kg^{-1} and 17.9 MJ kg^{-1} [2], suggesting canola straw could be a suitable combustion fuel for renewable energy generation if it is compared with barley straw, 18.5 MJ kg^{-1} or willow 19.15 MJ kg^{-1}. The development of a market for canola straw as a fuel would add value to the gross margin of the crop at farm level.

Straw typically has a low bulk density, ranging from 50 kg m^{-3} (forage harvest straw) to 240 kg m^{-3} (high density bale) [3]. The relative low density of straw makes it more expensive to transport compared to wood chips (150 kg m^{-3} to 300 kg m^{-3}), house coal (850 kg m^{-3}) and anthracite (1100 kg m^{-3}). This also means larger storage area/volume is required for baled straw compared to wood chips. Densification into pellets increases the bulk density of biomass [4], and as a result, the net calorific content per unit volume is

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Table 1 – Description of canola straw storage periods and date of sample.

Straw sample	Year of harvest	Storage period (months)	Date of analysis
B3 2008	2008	3	20th October 2008
B4 2008	2008	4	17th November 2008
B7 2008	2008	7	9th February 2009
B10 2008	2008	10	4th May 2009
B20 2008	2008	20	8th February 2010
B0 2009	2009	0	13th July 2009
B1 2009	2009	1	10th August 2009
B3 2009	2009	3	5th October 2009
B7 2009	2009	7	11th January 2010

increased and the storage, transport and handling of the material are easier and less expensive [5].

Straw, as many other agricultural products, is normally held under storage for variable periods of time, typically up to one year. However, unlike relatively high value products such as cereal grain and animal feed, the effect of post-harvest storage on the quality of straw has not been comprehensively investigated. Microbial growth and subsequent heat development within piles of wood chip is well documented in the literature [6]. In addition, the consequences of microbial growth on wood chip fuel quality have also been studied and include changes in the chemical constituents of the material [7], dry matter losses, changes in the moisture content, and the generation of dust and fungal spores. These could lead to serious adverse health effects in people handling the materials, such as eye irritation and respiratory diseases [8,9]. Previous studies [10,11] have demonstrated wheat and barley straw are colonised by a series of bacteria, yeast and filamentous fungi during growth, senescence, harvesting and storage. The microbial colonisation and decomposition of wheat straw over storage has been studied [11]. However, this research did not investigate the relationship between the microbial populations during storage and variations in the environmental conditions, such as ambient temperature and relative humidity, and chemical and physical properties of the straw, such as C:N ratio.

Previous research investigated the quality of sawdust, logging residues and bark pellets produced from freshly harvested biomass [12]. The moisture content of the raw material ranged between 355 g kg^{-1} and 616 g kg^{-1} (wet basis). It is suggested biomass with a moisture content of less than 120 g kg^{-1} prior to pelletisation is required to ensure stable and durable pellets are produced [4]. Thus, biomass with high moisture content must be dried to below 120 g kg^{-1} prior to pelletisation. This adds to the energy requirement and operation cost of the pelletisation process. Thus, the use of biomass with low moisture content would provide an advantage.

Whilst research has been conducted that investigates the effect of storage of wood and forestry residues [12–14] in terms of microbial growth and fuel properties, there has been no research to date that has investigated the effect of storage on microbial growth on canola straw bales and pellets. The objective of this study was to determine the effect of on-farm storage of baled (up to 20 months storage) and pelletised (up to 48 weeks storage) canola (*B. napus*) straw, from two harvest years (i.e. 2008 and 2009), on a) microbial growth b) moisture content c) carbon-to-nitrogen ratio and d) the relationship between microbial growth and straw properties and temporal environmental conditions (temperature and relative humidity)

2. Materials and methods

2.1. Canola Straw

Canola straw (cv Excalibur) bales were harvested and collected from Church Farm (Lat. N 52:01:56 Long. W 0:13:55) (Astwick, Stotfold, Hitchin, Herts, UK) in 2008 and 2009. Canola straw collected in 2008 was swathed on the 7th July 2008, harvested on the 21st July 2008, baled on the 25th July 2008 and stored outdoors and uncovered until the 22nd August 2008. Canola

Table 2 – Description of the canola straw pellets storage periods and date of sample analysis.

Pellet sample	Length of storage of canola straw bale before pelletisation (months)	Length of storage of canola pellets after pelletisation (weeks)	Date of analysis
B3 2008 2	3	2	3rd November 2009
B3 2008 4	3	4	17th November 2009
B3 2008 12	3	12	12th January 2009
B3 2008 24	3	24	6th April 2009
B3 2008 48	3	48	21st September 2009
B7 2008 2	7	2	23rd February 2009
B7 2008 4	7	4	9th March 2009
B7 2008 12	7	12	4th May 2009
B7 2008 24	7	24	27th July 2009
B10 2008 2	10	2	18th May 2009
B10 2008 4	10	4	1st June 2009
B10 2008 12	10	12	27th July 2009
B10 2008 24	10	24	19th October 2009
B3 2009 2	3	2	19th October 2009
B3 2009 4	3	4	2nd November 2009
B3 2009 12	3	12	28th December 2009
B3 2009 24	3	24	22nd March 2010