Growth stage and ensiling effects on ruminal degradability of whole-crop oats

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Dairy sector

Cattle farming
Introduction

• Increasing home-grown forage production and utilization
• Alternative forage crops
• Whole crop cereals
• Growth stage and silage conservation
Objective

This study evaluated the effects of growth stage and ensiling of whole-crop oats on in situ ruminal dry matter degradability.
Materials and methods

- **Grain-type oats** (*Avena sativa* cv. Cantara)
- **Randomized Complete Block Design**: 3 replicates/ Treatment
Materials and methods

• Treatment = Harvest and **ensiling** at **6 stages of growth**
Materials and methods

- Harvested and ensiled at **6 stages of growth**
- **Zadoks cereal growth stage key** (Zadoks et al. 1974)

GS 45  GS 59  GS 69  GS 73  GS 83  GS 91
Materials and methods

- Harvested and ensiled at 6 stages of growth
- Zadoks cereal growth stage key (Zadoks et al. 1974)

Days post-sowing

<table>
<thead>
<tr>
<th>Days</th>
<th>Stage</th>
</tr>
</thead>
<tbody>
<tr>
<td>125</td>
<td>GS 45</td>
</tr>
<tr>
<td>132</td>
<td>GS 59</td>
</tr>
<tr>
<td>139</td>
<td>GS 69</td>
</tr>
<tr>
<td>146</td>
<td>GS 73</td>
</tr>
<tr>
<td>161</td>
<td>GS 83</td>
</tr>
<tr>
<td>170</td>
<td>GS 91</td>
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</tbody>
</table>
Materials and methods

**Harvest**
- Small scale forage harvester
- Stubble height 15 cm
- Same daytime (13.00 h)

**Chop**
- Particle size 2-4 cm

**Ensiling**
- Manual press
- 22 L drums
- Hermetically sealed
- 64 days ensiling
Materials and methods

• In situ ruminal degradation kinetics of **fresh and ensiled forage**

• **Pooled samples** from the same stage of growth
In situ ruminal degradation kinetics of fresh and ensiled forage

Pooled samples from the same stage of growth

3 cows fitted with rumen cannulas

- Diet 2/3 Forage + 1/3 concentrate
- Vitamin and mineral mixture
- 20 days of adaptation period
Materials and methods

• In situ ruminal degradation kinetics of fresh and ensiled forage
• Pooled samples from the same stage of growth
• 3 cows fitted with rumen cannulas

• Incubation
  ✓ Dried 60°C – Ground 2 mm
  ✓ 7 g placed in Nylon bags
  ✓ 3, 6, 12, 24, 48, 72, 96 h
  ✓ 2 series
  ✓ Removal / washed/ dried
Materials and methods

• Data was fitted model proposed by Ørskov and McDonald (1979):

\[ d = a + b \left( 1 - e^{-kd \times t} \right) \]

\[ \begin{align*}
  d: & \quad \text{material lost from the bag at time } t \\
  a: & \quad \text{soluble fraction} \\
  b: & \quad \text{insoluble degradable fraction} \\
  kd: & \quad \text{fractional degradation rate of } b \ (\text{/h}) \\
  u: & \quad \text{undegradable fraction } u = 1 - (a + b)
\end{align*} \]
Materials and methods

• Data was fitted model proposed by Ørskov and McDonald (1979):

\[ d = a + b \left(1 - e^{-kd \times t}\right) \]

• Effective degradability:

\[ ED = a + \frac{(b \times kd)}{(kd + kp)} \]

Rumen particle outflow rate (kp):
0.03 /h low flow rate
0.06 /h high flow rate
Statistical analysis

• Effects of **growth stage**, **ensiling** and their **interaction** were analysed using the SAS MIXED procedure.

\[ Y_{ijk} = \mu + GS_i + E_j + (GS * E)_{ij} + B_k + \varepsilon_{ijk} \]

- **GS** \(_i\) Growth stage \(i = 6\) growth stages
- **E** \(_j\) Ensiling \(j = \) fresh and ensiled forage
- **GS** * **E** \(_{ij}\) Interaction

• **Linear** and **quadratic regressions** for growth stage.
Results and Discussion

- Fresh forage
- Ensiled forage
Effective degradability

Growth stage (days)

ED06

Fresh forage  Ensiled forage

E  P<0.01
GS  P<0.01
E*GS  P<0.01
Soluble fraction (a)

- Fresh forage
- Ensiled forage

Growth stage (days):
- 125
- 130
- 135
- 140
- 145
- 150
- 155
- 160
- 165
- 170

Statistical significance:
- E P<0.01
- GS P<0.01
- E*GS P<0.01
Insoluble degradable fraction (b)

Growth stage (days)

Fresh forage  Ensiled forage

E  P<0.01
GS  P<0.01
E*GS  ns
Fractional degradation rate ($k_d$)

- Growth stage (days):
  - 125 130 135 140 145 150 155 160 165 170

- Data points:
  - Fresh forage: Green dots
  - Ensiled forage: Orange dots

- Statistical significance:
  - $E$: $P<0.01$
  - $GS$: $P<0.01$
  - $E*GS$: $ns$
In summary...

• **Effect of GROWTH STAGE**
  - Changes in the plant chemical composition
  - Plant maturation

• **Effect of ENSILING**
  - Changes in the chemical composition of ensiled forage
  - Silage fermentation
What changes in chemical composition occurred with increasing crop maturity?
1. Increase of Cell Wall Components

![Graph showing the increase of cell wall components over different growth stages.](image)

- **NDF** and **ADF** are illustrated on the graph.
- The graph shows the growth stage (days) on the x-axis and the concentration of cell wall components (g/kg DM) on the y-axis.
- Growth stages include: Boot, Heading, Water ripe.

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**Graph Key:**
- NDF: Red Circle
- ADF: Red Diamond

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**Legend:**
- NDF: Neutral Detergent Fiber
- ADF: Acid Detergent Fiber
1. Increase of Cell Wall Components

![Graph showing the increase of Lignin (g/kg DM) over growth stage (days).]
2. Decrease of WSC

![Graph showing the decrease of WSC (g/kg DM) over time (days)]

- **WSC (g/kg DM)**
- **Growth stage (days)**

- Boot
- Heading
- Water ripe
3. Increase of Starch

Starch (g/kg DM)

Growth stage (days)

Early milk  Early dough  Grain ripe
What changes in chemical composition occurred after ensiling?
1. WSC fermentation

![Graph showing WSC (g/kg DM) over growth stages from Boot, Heading, Water ripe, to Early milk.](image)
2. Hydrolysis of Hemicellulose

The graph shows the hydrolysis of hemicellulose over the growth stages of crops. The horizontal axis represents the growth stage in days, while the vertical axis shows hemicellulose concentration in g/kg DM. The graph illustrates the trend of hemicellulose concentration as the growth stage progresses, indicating its hydrolysis over time. The early dough and grain ripe stages are marked for reference.
2. Hydrolysis of Starch
Effect of growth stage

Increase of Cell wall components
Decrease of WSC

Increase of Starch

Growth stage (days)

WSC

Boot  Heading  Water ripe  Early milk  Early dough  Grain ripe
Effect of ensiling

Growth stage (days)

WSC fermentation

Hydrolysis Hemicellulose Starch

Heading Water ripe Boot Early milk Early dough Grain ripe
**Growth stage:**
- Strongly influenced chemical composition.
- Negative effect on DM degradability of whole crop oats.
- Starch compensated the high levels of lignin.

**Ensiling:**
- Reduced forage nutritive value and ruminal fermentation at some stages of growth.
- This reduction had less impact in comparison with the effect of growth stage.
Implications

Understanding the changes that occur across Avena sativa *cv. Cantara* stages of growth will allow to harvest the crop at the desired moment and to achieve a good quality silage.
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