Effect of sainfoin (*Onobrychis viciifolia*) silage on feed digestibility and methane emission in cows

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Fermentation end products

- VFAs
- Microbial Protein
- Methane

Energy loss up to 15%
(Johnson et al., 1993)

- Improve economic advantage
- Reduce global warming

World methane gas emission by agriculture sector

- Livestock & Manure 37.8%
- Rice Cultivation 11.1%
- Others Agriculture 6.7%
- Agriculture Soils 44.4%

World Resource Institute, (2000)
Rumen fermentation

- Cellulose
- Starch
- Sugar

Hexose

Pyruvate

- $H_2$
- $CO_2$
- $CH_4$

Acetyl-CoA

- Acetate
- Butyrate

Lactate

- 2H

Oxaloacetate

- 4H

Acrylyl-CoA

Succinate

Propionate
Mitigation strategies for methane emission

**Improve nutrients:**
High levels of starch-based concentrate $\downarrow$ CH$_4$, by $\uparrow$ C3 (Beauchemin and McGinn 2005)

**Feed additives**
Essential oils
$\downarrow$ CH$_4$ by up to 46%.
Chiquette and Benchaar (2005)
Oil were toxicity of methanogen and protozoa cell membrane (Machmüller et al. 1998).

**Plants secondary metabolite compounds**
Plants rich in condensed tannins, saponin have been shown to $\downarrow$ CH$_4$ by $\downarrow$ rumen methanogenesis in sheep and cattle (Waghorn, 2002).
Condensed tannins (CT)

- Tannin-protein complex in the rumen
  - Decreased rate of protein degradation
  - Decreased urinary-N Excretion

Inhibition of some rumen:
- Bacteria
- Fungi
- Protozoa

- Inhibition of methanogens
  - Reduced methane production

- Reduced rate of fermentation

- Decreased incidence of bloat

Protected environment

(Patra and Saxena, 2010)
Introduction

Sainfoin (Onobrychis viciifolia)

+ Adapt well to dry hilly environments on calcareous soils
+ Biomass about 10-15 ton/ha/year
+ 20-22% CP (Guglielmelli et al., 2011)
+ Rhizobial bacteria → Binds nitrogen in the soil
+ Low phosphor need
+ Contain condensed tannin (CT) (Guglielmelli et al., 2011)
Positive effects of sainfoin:

- High palatability
- High nutritive value
- Better protein utilization
- Anthelmintic function
- Bloat resistant
- Reduce methane production

(Carbonero et al., 2011)
Objective

To determine effect of Sainfoin silage in TMR diet on feed digestibility and CH$_4$ emission
Materials and Methods

Experimental design:

**Periods**
- **Period 1** (25 days)
  - Cow 1
  - Cow 2
  - Cow 3
- **Period 2** (25 days)
  - Cow 4
  - Cow 5
  - Cow 6

**Dietary treatment**

<table>
<thead>
<tr>
<th>Ingredients</th>
<th>CON</th>
<th>SAIN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grass silage</td>
<td>56.35</td>
<td>26.19</td>
</tr>
<tr>
<td>Sainfoin silage</td>
<td>0</td>
<td>33.27</td>
</tr>
<tr>
<td>Maize silage</td>
<td>10.41</td>
<td>9.66</td>
</tr>
<tr>
<td>Concentrate</td>
<td>26.61</td>
<td>24.72</td>
</tr>
<tr>
<td>Linseed</td>
<td>6.63</td>
<td>6.16</td>
</tr>
</tbody>
</table>

Sainfoin Making silage
Materials and Methods

Measurement nutrition digestibility, nitrogen utilization, $\text{CH}_4$ production:

- Feed intake and residues: morning + afternoon
- Feces: during 4 days measurements
- Milk production: morning + afternoon
- $\text{CH}_4$ production using respiration chambers for 4 days
- Parameters: DM, OM, NDF, ADF, N, and GE

21 days for adaptation  4 days for measurements
<table>
<thead>
<tr>
<th>Items</th>
<th>Dietary treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CON</td>
</tr>
<tr>
<td>Chemical composition (g/kg DM)</td>
<td></td>
</tr>
<tr>
<td>DM, g/kg product</td>
<td>444.9</td>
</tr>
<tr>
<td>GE, MJ/kg DM</td>
<td>19.5</td>
</tr>
<tr>
<td>OM</td>
<td>918.9</td>
</tr>
<tr>
<td>CP</td>
<td>162.6</td>
</tr>
<tr>
<td>NDF</td>
<td>395.7</td>
</tr>
<tr>
<td>ADF</td>
<td>236.8</td>
</tr>
</tbody>
</table>

Chemical compositions *were similar* between the two diets.
### Table 2. Effect of sainfoin silage on feed intake

<table>
<thead>
<tr>
<th>Items</th>
<th>Dietary treatment</th>
<th>SEM</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CON</td>
<td>SAIN</td>
<td></td>
</tr>
<tr>
<td>Nutrient intake, (kg/d)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DM</td>
<td>17.8</td>
<td>18.7</td>
<td>1.04</td>
</tr>
<tr>
<td>OM</td>
<td>16.3</td>
<td>16.6</td>
<td>0.94</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>0.47</td>
<td>0.52</td>
<td>0.03</td>
</tr>
<tr>
<td>NDF</td>
<td>7.0</td>
<td>6.7</td>
<td>0.38</td>
</tr>
<tr>
<td>ADF</td>
<td>4.2</td>
<td>4.6</td>
<td>0.25</td>
</tr>
</tbody>
</table>

- DM, OM and NDF intake **were similar** between the two diets
- Nitrogen and ADF intake **were higher** in the SAIN diets
Table 3. Effect of sainfoin silage on nutrients digestibility

<table>
<thead>
<tr>
<th>Items</th>
<th>Dietary treatment</th>
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<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>CON</td>
<td>SAIN</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DM (g/kg)</td>
<td>727.9</td>
<td>688.2</td>
<td>0.4</td>
</tr>
<tr>
<td>OM (g/kg)</td>
<td>746.7</td>
<td>717.7</td>
<td>0.3</td>
</tr>
<tr>
<td>NDF (g/kg)</td>
<td>667.9</td>
<td>577.3</td>
<td>0.7</td>
</tr>
<tr>
<td>ADF</td>
<td>658.2</td>
<td>573.5</td>
<td>1.3</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>661.6</td>
<td>650.7</td>
<td>13.1</td>
</tr>
</tbody>
</table>

- The DM, OM, NDF and ADF digestibility were lower in the SAIN diet.
Table 4 Effect of sainfoin silage on milk yield and composition

<table>
<thead>
<tr>
<th>Items</th>
<th>Dietary treatment</th>
<th>SEM</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CON</td>
<td>SAIN</td>
<td></td>
</tr>
<tr>
<td>Milk yield (kg/d)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Milk</td>
<td>22.0</td>
<td>24.1</td>
<td>2.84</td>
</tr>
<tr>
<td>Milk/OM digested (kg)</td>
<td>1.8</td>
<td>2.0</td>
<td>0.11</td>
</tr>
<tr>
<td>FPCM</td>
<td>24.1</td>
<td>25.7</td>
<td>2.73</td>
</tr>
<tr>
<td>Milk composition (g/kg)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fat</td>
<td>48.5</td>
<td>47.0</td>
<td>1.43</td>
</tr>
<tr>
<td>Protein</td>
<td>35.4</td>
<td>33.9</td>
<td>2.20</td>
</tr>
<tr>
<td>Lactose</td>
<td>44.5</td>
<td>45.0</td>
<td>0.90</td>
</tr>
</tbody>
</table>

- Milk yield was highest in the SAIN diet
- Milk compositions were similar between the two diets
Table 5. Effect of sainfoin silage on methane emission

<table>
<thead>
<tr>
<th>Items</th>
<th>Dietary treatment</th>
<th></th>
<th>SEM</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CON</td>
<td>SAIN</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CH₄, g/d</td>
<td>365.5</td>
<td>360.8</td>
<td>19.85</td>
<td>0.68</td>
</tr>
<tr>
<td>CH₄, g/kg DMI</td>
<td>20.6</td>
<td>19.4</td>
<td>0.30</td>
<td>0.005</td>
</tr>
<tr>
<td>CH₄, g/kg milk</td>
<td>17.6</td>
<td>15.5</td>
<td>1.71</td>
<td>0.16</td>
</tr>
<tr>
<td>CH₄, g/kg FPCM</td>
<td>15.8</td>
<td>14.4</td>
<td>1.18</td>
<td>0.22</td>
</tr>
<tr>
<td>CH₄, % of GEI</td>
<td>5.9</td>
<td>5.7</td>
<td>0.09</td>
<td>0.06</td>
</tr>
</tbody>
</table>

- CH₄ was lowest in the SAIN diet
- CH₄ as a percentage of GEI tended to be lower in the SAIN diet
Discussion

- **Nutrients digestibility**
  
  Scharenberg et al. (2007) also found that the apparent digestibility of OM, NDF and ADF were lower for lambs fed sainfoin silage (contained about 5g CT/kg DM), compared with lambs fed grass-clove silage. In our study, CT=8.8 g/kg DM

- CT may make complex with lignocellulose, thus preventing microbial digestion. CT could directly inhibiting cellulolytic microorganism and activities of fibrolytic enzymes (Patra and Saxena, 2009)
Methane production

Woodward et al. (2002) found that CH$_4$ emission per kg DM intake was lower in the cows fed Hedysarum coronarium (CT-containing forage), compared with cows fed perennial ryegrass.

Saifoin contains CT, a plant secondary metabolite that have been show to reduces ruminal methanogenesis and decrease ruminal protozoa number in some study (Tavendale et al., 2005; Batta et al., 2009)

- Decrease fibre degradation → Reduced acetate → reduced H$_2$ for CH$_4$ production (Beauchemin et al., 2009)
Take home message

- Sainfoin silage could be used in TMR diet to improve milk production and reduce CH4 per kg DM intake
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Thank you kindly for your attention!

Vietnamese lotus flower