Slowly Fermentable Grains May Reduce Metabolic Heat and Ameliorate Heat Stress in Grain-Fed Sheep


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• Ruminants can be more susceptible to **Heat stress** (Coppock, 1985; Goetsch and Johnson, 1999; Roy and Collier, 2012).

• Rapidly fermentable grains (**wheat**); digestive disorders, laminitis and higher metabolic heat **production** (Nocek, 1997; Oetzel and Smith, 2000; Stone, 2004, Grant and Albright, 1995; Brosh et al., 1998; Mader et al., 1999).

• Slowly fermentable grains (**corn**); better utilization of ME and reduction of the heat from fermentation (Ørskov, 1986; Owens et al., 1986).
Objectives

• To characterise the *in vitro* gas production kinetic parameters of wheat and corn grains.
• To compare physiological parameters of sheep fed either *slowly* or *rapidly* fermentable grain-based diets under heat stress conditions.

Hypotheses

• Wheat has a faster rate of *in vitro* fermentation than corn.
• Feeding *slowly fermentable grains* can reduce the impact of heat stress in grain-fed sheep.
**In Vitro Experiment**

- 28 replicates of 1g of 1mm-ground wheat ASW 10% (70% starch) and corn (74% starch).
- Buffered rumen fluid (Kansas-State buffer pH 6.8) ratio 1:3
- Gas recording modules ANKOM$^{RF}$ Wireless system every 5 minutes
- Incubated for 24 h at 39°C
In Vivo experiment

Experimental Design
Randomized Control Trial

Animals
- 22 Merino X Poll Dorset crossbred wether lambs.
- 11-12 mo
- 41.2±2.4 Kg BW
- Fleece cover 3 cm
Diets

- **Control - rapidly fermentable diet** “Wheat Diet”
  50% crushed wheat grain + 50% of oaten/lucerne chaff

- **Intervention - slowly fermentable diet** “Corn Diet”
  50% crushed corn grain + 50% of oaten/lucerne chaff

**Both**: 4% DM Balanced Supplement
12.7 % CP, 11.9 MJ ME/Kg DM,
23.8% NDF and 37.9% starch
Fed three times a day (0900, 1300, 1700h)
Accl. (15 d)

- **Acclimation feeding** (1.5 x Maintenance requirements)

Period 1 (P1, 7d)

- **Thermoneutral** (18 to 21°C and 40-50% RH, 24 h)
- **Restrictive feeding** (1.3 x Maintenance requirements)

Period 2 (P2, 7d)

- **Heat stress** (38°C/ 30% RH; 0900 to 1700 h, 28°C/50% RH;1700 to 0900 h)
- **Restrictive feeding** (1.3 x Maintenance requirements)

Period 3 (P3, 7d)

- **Heat stress** (38°C/ 30% RH; 0900 to 1700 h, 28°C/ 50% RH;1700 to 0900 h)
- **Acclimation feeding** (1.5 x Maintenance requirements)
• Respiration rate (RR)

• Rectal temperature (RT)

• Left and right flank skin temperature (LST and RST)
  • 0900, 1300, 1700 and 2100h during the experiment.

• Feed /water intake
In vitro gas production

- Gas production curve was fitted to the Gompertz model. REML using the statistical package GenStat (GenStat release 14; VSN International Ltd., Hemel Hempstead, UK)

\[ Y = A + C \exp \left( -\exp \left( -B(X-M) \right) \right) \]

Where:
- \( B \) = Rate of gas production (mL h\(^{-1}\))
- \( M \) = Time at which the maximum rate of gas production is reached (h)
- \( C \) = Maximum gas produced (Max \(_{\text{gas}}\) mL/g DM)
- \( A \) = Y-intercept
**In vivo experiment**

- Restricted Maximum Likelihood (REML) analysis procedure for GenStat

- True differences between left and right flank skin temperature were estimated by conducting a t-Test.
Corn had slower rate of gas production (ml gas h$^{-1}$) than wheat ($P<0.001$). Wheat reached the maximum rate of gas production earlier than corn ($P<0.001$).

- Protein Matrix
- Amylose content
- Resistance to bacterial enzymatic attack

![Graph showing gas production over time for Corn (74% Starch) and Wheat (70% Starch).](image)

- Max Rate 6.8 h for Wheat
- Max Rate 8.7 h for Corn
Heat stress increased RR ($P<0.001$) and corn-fed sheep had lower RR across periods ($P<0.001$).

**Graph:**
- **Respiration Rate, breaths per minute**
- **Conditions:**
  - Thermoneutral (P1, 1.3 x M)
  - Heat Stress (P2, 1.3 x M)
  - Heat Stress (P3, 1.5 x M)
- **Species:**
  - Corn
  - Wheat
Corn-fed sheep showing lower RR at 38°C/30% RH
Heat stress increased RT ($P<0.001$), Corn-fed sheep had lower RT at high ambient temperature ($P<0.001$).
Skin temperature increased with heat stress ($P < 0.001$). Corn-fed sheep had lower skin flank temperature ($P < 0.001$). LST was higher than RST ($P < 0.001$).
Wheat-fed sheep had larger difference between left and right flank skin temperature ($P<0.001$)

(Laue and Petersen, 1991; Montanholi et al., 2008)
CONCLUSION

• Corn grain had slower fermentation rate than wheat grain
• Feeding a corn-based diet reduced the total heat increment.
• Corn grain diet ameliorated the physiological responses negatively affected by HS in grain-fed sheep compared to dietary wheat.
• Higher feed intake increased the thermal load of the animals under HS.
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