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ENTERIC METHANE EMISSIONS FROM RUMINANTS FED FORAGES: A META-ANALYSIS ON THE ROLE OF TANNINS CONTENT

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ABSTRACT: Enteric methane emission by ruminants fed forages is highly variable and depends on forage composition, intake and digestibility. In addition, plant secondary compounds such as tannins have antimethanogenic properties; however, the mitigating effect of tannins on CH₄ is inconsistent. A meta-analysis approach was used to compare the effects of different forages, supplemented or not with tannins, fed to ruminants on CH₄ emission. Tannin content (TAN, condensed or hydrolysable), averaged 35.6 (sd =53.0) g/kg DM and varied from 0 to 199 g/kg DM, for 19 experiments and 53 treatments. Methane production, expressed per kg of digestible OMI (g/kg DOMI) significantly decreased when feeding level (FL, calculated as DM intake % liveweight) increased and when NDF content of the forage decreased. Moreover, tannins content (g/kg DM) decreasing effect on methane emission was significant. The effect of tannins for mitigating CH₄ emission is in agreement with previous studies, but in the present study the impact of tannins was lower, probably due to accounting for decreasing effect of FL and increasing effect of NDF effects in the equation and to small relations between these factors.

Keywords: enteric methane, forage, meta-analysis, tannins, emission factor

INTRODUCTION: Feeding forages, especially those rich in protein (legume), could represent an interesting strategy to both provide N to the animal and decrease methane emissions, thus enhancing animal productivity and reducing climate change. Forages rich in plant secondary compounds, such as tannins have been studied both for their nutritional effects (positive or negative) on animal productivity (Reed, 1995) and also for their antimethanogenic properties (Doreau et al., 2011; Jayanegara et al., 2012). However, the mitigating effect of tannins on CH₄ is inconsistent (Beauchemin et al., 2008; Makkar, 2003). The objectives of this study were first to estimate CH₄ emission of ruminants fed forages based on intake level, crude protein (CP) and neutral detergent fibre (NDF) forage content, then to go further and evaluate the effect of tannins content. A meta-analysis approach (Sauvant et al., 2008) was used to compare the effects of different forages, supplemented or not with tannins, fed to ruminants on CH₄ emissions.

1. MATERIAL AND METHODS:

1.1. Data collection: We collected published data (Web of Science, CAB) that reported, on the same treatment, dry matter intake (DMI), CH₄ emissions, digestibility parameters, and forage chemical composition. The whole database contained 103 publications, 205

experiments and 554 data on CH₄ emission. Tannins contents (condensed or hydrolysable), was reported only in 19 experiments (sub dataset) and averaged 35.6 (sd=53.0) g/kg DM and varied from 0 to 199 g/kg DM. There was different forage species containing either condensed tannins or hydrolysable tannins in the dataset.

1.2. Data statistical analysis: We applied a meta-analysis based on Sauviant et al. (2008) on the sub dataset to estimate CH₄ emission. The main factors tested (Proc GLM, Minitab 16) were CP, NDF, acid detergent fibre (ADF) contents of the forage, digestibility of OM (DOM), feeding level is DMI expressed as % of live weight (DMI %LW) and log₁₀ 1+ tannins content (log₁₀ (1+TAN)) as covariates and animal species (cattle, sheep, goat) and experiment as qualitative factors. Qualitative factors were considered as fixed effects tested on inter-experiment-intra-factor variance. Log transformation of (1+ TAN) was required to achieve normal distribution of data and to include data where TAN=0. Outlier treatments were removed when their normalized residues were >3.

2. RESULTS:

Effects of tannins on CH₄ emission:

As previously observed (Eugène et al., 2014), methane production, expressed per kg of digestible OMI (g/kg DOMI) was significantly related to DMI%LW and NDF content of the diets. Moreover, this study indicates that TAN (g/kg DM) content of the diet can be taken into account:

$$\text{CH}_4/\text{DOMI} = 33.83 - 3.18 \text{ FL} + 0.018 \text{ NDF} - 3.21 \text{ Log}_{10} (1+\text{TAN}) \quad (1)$$

(nt = 53 treatments, nexp = 17 experiments, RMSE = 3.3 g/kg, R² adj = 68%, P < 0.001)

Where CH₄/DOMI (32.1 ± 8.6, min = 11.0, max = 48.8 g CH₄/kg DOMI) is the methane production per kg of digestible OMI, FL is the feeding level (DMI expressed as %LW), NDF the dietary NDF content (g/kg DM, limit of significance, p<0.10) and TAN is the dietary tannin content (g/kg DM).

Table 1. Main descriptive parameters (number of observations (n), mean, sd, min, max) of chemical composition of the diets, feeding levels (DMI%LW), OM digestibility (DOM) and CH₄ emission factors, in the sub dataset (19 experiments).

	n	mean	sd	min	max
Chemical composition ¹					
CP (g/kg DM)	66	180.0	60.4	93	300
NDF (g/kg DM)	65	472	148	147	764
ADF (g/kg DM)	45	336	87	145	490
Tannins (g/kg DM)	69	36	53	0	199
DMI/LW (%)	69	2.3	0.9	0.5	4.9
DOM (%)	61	64.0	10.8	42.3	81.6
Methane emission factors					
CH ₄ (g/kg DMI)	69	19.04	5.51	6.67	33.70
CH ₄ (g/kg DOMI)	61	32.11	8.65	10.97	48.78

¹Chemical composition content of the diet (g/kgDM): CP: crude protein, NDF: neutral detergent fiber, ADF: acid detergent fiber, Tannins: tannins contents.

3. DISCUSSION AND CONCLUSION:

Similarly to a previous study (Sauvant et al., 2011) we observed that DMI%LW decreased CH₄ emissions. It's the main factor that explain CH₄ variations, but moreover, we observed that NDF contents in forages increased significantly CH₄ emissions, whereas tannins contents decreased it. The decreasing effect of tannins on CH₄ emission was in agreement with Jayanegara et al. (2012). But in the present study the impacts of tannins were lower presumably because of the significant decreasing effect of FL and increasing effect of NDF effects. Indeed, increased NDF content of forages induced increased fermentation and thus lead to increased CH₄ production (Eugène et al., 2014). Further analysis and studies are needed in order to test the effect of the source of tannins because there are too few direct comparisons within a same study in the literature.

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