In-vivo effects of natural additives on ruminant methanogenesis, a meta-analysis approach

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Introduction Mitigation of methane (CH4) represents not only an environmental interest for the planet but also a nutritional interest for ruminants (Martin *et al*., 2010). The use of feed additives was developed to improve ruminant performances and they are also tested to reduce CH4 emission. A review (Benchaar *et al*. 2011) described the potential use of feed additives as CH4 mitigation strategies in ruminants The aim of this study was to quantitatively evaluate the effect of natural additives containing tannins, saponins and essential oils on in vivo methanogenesis. The objectives were: 1 / quantify the impact of natural additives on CH4 emissions in ruminants using published data, and for those additives reducing CH4, 2 / evaluate their impact on animal performances.

Material and methods A meta-analysis statistical approach (Sauvant *et al*., 2008) was used to compare the effect on methane emissions of different additives (tannins, saponins and essential oils) supplemented to ruminants. A quantitative review was performed on available published data (Web of Science, CAB ...) that reported both criteria, on the same animal, of dry matter intake, CH4 emissions, digestibility parameters, feed chemical composition and additives content (secondary metabolites of plant extracts) in the diet. For this purpose, a database was compiled from studies from literature. The main factors tested in statistical analyses (Proc GLM, Minitab 2007) were crude protein content (CP) of the diet, OM total tract digestibility, level of intake (DMI), animal species, secondary compound's content of the diet and study effect.

Results: The database contained 32 publications and 108 treatments on the effect of natural additives on CH4, where 19, 12 and 6 publications tested the effect of tannins, saponins and essential oil, respectively. Additives 'dose and source were variable, they were included in forage, concentrate or given as feed supplements and fed to different animal species (cow, sheep and goat). Means (± s.d.) of some variables in our database are presented for each additive and ruminant species (table 1). The effect of additive family and animal species were included in the statistical analysis but failed to be significant, in our study. The secondary metabolites plant content was a significant factor explaining CH4 variation in our database. Furthermore, CP content of the diet was also a significant factor, decreasing root mean standard error (RMSE) and enhancing the relationship between CH4 and secondary metabolites plant content (equation 1).

- **CH_4** (g/kg DMI) = 34.4(±3.72) – 0.07 (0.011) **Secondary metabolites** (g/kg DMI) –0.1 (0.02) **CP**(g/kg DMI)
- n= 85 treatments, n=32 trials, RMSE=1.6 g/kg DMI, R^2 adjust.=87.7% $P<0.05$ **(equation 1)**

Our meta-design, which was not well balanced, could not allow us to compare the 3 additives within the same study. Only 12 publications have tested the effect of plant extracts on CH4 and animal performances (50% on milk production and 50% on meat production). This may explain why we did not observe any relationship between CH4 decrease caused by additive supplementation and animal performances.

Table 1 CP, secondary metabolites, DM intake, OM digestibility and CH4, of the database (mean ± (s.d.)).

	Saponin			Tannin			Essential oil		
	cow	sheep	goat	cow	sheep	goat	cow	sheep	goat
CP(g/kg DMI)	161 (13.2)	133.3 (24.1)	-	186 (45.7)	164 (69.7)	126 (14.5)	151 (13.4)	149.5 (44.4)	-
DMI (kg/BW0.75)	139 (47.3)	66.6 (13.2)	-	109 (41.9)	63.3 (17.9)	52.5 (7.9)	119.1 (27.8)	58.6 (23.16)	-
Secondary metabolites (g/kg DM)	5.5 (4.93)	5.0 (9.90)	-	11.9 (12.27)	9.73 (17.15)	81 (74.5)	6.5 (7.99)	0.6 (0.92)	-
OM total tract digestibility (%)	-	65.1 (7.9)	-	79.3 (2.91)	64.9 (7.57)	60.6 (8.02)	-	67.5 (5.68)	-
CH4 (g/kg DM)	19.0 (2.88)	18.2 (3.16)	-	19.4 (5.55)	17.8 (4.33)	16.6 (5.97)	21.4 (6.02)	19.6 (6.16)	-

Conclusions These results show that secondary metabolites supplementation decreased CH4 and this may be explained by antimicrobial properties of the additives (Doreau *et al*. 2011). An additional decrease was observed when there was an increase of CP content in the diet, after additive supplementation. However, in our study, there was no significant relationship between CH4 decrease and meat or milk production.

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