Environmental impact of three high-concentrate diets fed to bulls

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Introduction Bull fattening, as other farming activities, results in emissions of pollutants to air, water and soil and the use of resources (energy, land). In a trial carried out on bulls fattened with 3 diets containing 37 to 86% concentrates, enteric methane production was determined. The 86%-concentrate diet decreased enteric methane emission by more than 50% (Martin *et al.*, 2007). Enteric methane is only one of the pollutants and a comparison of feeding systems requires a more complete evaluation of the environmental impact. The data generated by this trial were analysed using life cycle assessment. Special attention was paid to emissions of greenhouse gases.

Materials and methods Three fattening diets have been compared in Blond d'Aquitaine bulls. Diet MSM comprised 63% maize silage, 21% maize grain and 16% soybean meal. Diet HM comprised 49% hay, 41% maize grain and 10% soybean meal. Diet M comprised 70% maize grain, 16% soybean meal and 14% straw. Enteric methane was determined in 6 animals in a 3x3 Latin square design using the SF_6 tracer method (Martin *et al.*, 2007). Manure methane was calculated from faecal data obtained in this trial using equations provided by IPCC (2006). Nitrous oxide and carbon dioxide emissions, eutrophication, acidification, terrestrial ecotoxicity and land use were calculated according to van der Werf (2004), updated according to IPCC (2006). Climate change was expressed as global warming potential in CO_2-eq using the coefficients 1, 25 and 298 for carbon dioxide, methane and nitrous oxide, respectively. Total cumulative energy demand was calculated according to Frischknecht *et al.* (2007). The life cycle assessment was limited to the production of the four feedstuffs used in the trial, the production of inputs to produce these feedstuffs and all transport stages, using the feed intake effectively measured in the trial. Each of the feeding systems was located in France, crop production methods and transport distances were based on average data for French farming systems. Data were expressed per day and per kg liveweight gain. Liveweight gain was taken as average daily gain between 400 and 650 kg in bulls receiving the same diets in a feeding experiment with 8 bulls per diet (Mialon *et al.*, 2008).

Results The lower enteric methane emission with diet M was partially compensated for by a higher emission of nitrous oxide and carbon dioxide (Table 1). Acidification and terrestrial ecotoxicity were highest with diet MSM and lowest with diet HM. Eutrophication was highest with diet M and lowest with diet HM, and cumulated energy demand was highest with diet M and lowest with diet MSM. Land use was highest with diet HM. Due to a higher liveweight gain, M diet environmental criteria were improved when expressed per kg liveweight rather than when expressed per day, compared to the other two diets.

Table 1 Emissions and environmental impacts from bulls fed three contrasting diets

	Per day			Per kg liveweight gain		
	MSM	HM	M	MSM	HM	M
Enteric methane, kg CO_2 eq	3.81	3.33	1.56	2.23	2.23	0.84
Manure methane, kg CO_2 eq	1.54	1.74	1.40	0.90	1.16	0.75
Nitrous oxide, kg CO_2 eq	1.37	1.15	2.03	0.80	0.77	1.09
Carbon dioxide, kg CO_2 eq	1.26	1.37	1.84	0.73	0.99	0.99
Global warming potential, kg CO_2 eq	8.02	7.65	6.89	4.70	5.12	3.70
Acidification, g SO_2 eq	29.6	13.1	22.6	17.3	8.8	12.1
Eutrophication, g PO_4^{3-} eq	24.1	16.3	31.9	14.0	10.9	17.1
Terrestrial ecotoxicity, g eq-1.4DB	36.9	11.5	19.7	21.6	7.7	10.6
Land use, m^2.year	7.77	17.51	8.63	4.54	11.72	4.63
Total cumulative energy demand, MJ eq	22.3	28.0	36.9	13.0	18.7	19.8

Conclusions The relative environmental performances of three bull fattening feeding systems are not the same for climate change as for other air pollution criteria, for soil and water pollution criteria or for energy demand. Diet M has lower impact on climate change, which is a major issue for ruminant production, but higher impact on energy demand. An integrative approach is necessary to compare feeding systems, and should include a total life cycle assessment including the early life stage of the animals, and other criteria of the impacts of these systems on the environment (water use, biodiversity).

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