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The relevance of methane emissions from beef production and the challenges of the Argentinean beef production platform

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ABSTRACT

The livestock sector faces the challenge to respond to the growing demand for animal protein from an expanding population while reducing environmental impact through GHG emissions. Globally about 2.836 million tons of CO_2-eq were emitted by the beef production sector equivalent to 46,2 kg CO_2-eq per kg carcass weight (CW). From the 1.485 million cattle head spread out over the world, 82% are on extensive grazing systems while only 18% are on high productive intensive systems. Among the top ten beef exporter countries, five are located in Latin America accounting a quarter of the global stock and two of them, Argentina and Uruguay, produce on temperate pastures under grazing systems. In Argentina, the livestock area was reduced in favor of increasing the grain cropping area, which took place in the last two decades. Production systems were intensified to maintain cattle stock. Cattle programs changed from 100% pasture to pasture supplemented with cereal grains and conserved forages, and confinement on grain feeding for fattening was incorporated. Due to land sharing competition with cash crops, no increment of cattle stock is expected therefore improving production efficiency appears as the only way to increase beef production while reducing methane emissions intensity. Beef produced on intensive grazing systems on supplemented pastures maintained organoleptic, nutritional and lipid profile than that of beef produced on pure grazing systems.

1. Introduction

In decades to come, the global demand for livestock products will continue to increase driven by the growing world population, increasing per capita incomes and rapid urbanization (Tilman, Balzerb, Hill, & Beforta, 2011). By 2050, the global population is projected to grow to nine billion people (United Nations, 2011). FAO (2012) analysis projects that demand for food will increase 60% in this period, and will double in many low-income countries (Garnett, 2010). Much of the new demand will be met by intensively raised livestock, and will occur in developing countries, in many cases on already vulnerable lands (Steinfeld et al., 2006).

In 2010, the ruminant sector contributed about 29 percent to global meat production (equivalent to 81 million tons) of which 79 percent was from the beef sector. The world cattle sector produces approximately 61,4 million tons of beef, of which 56 percent is produced by the specialized beef sector and 44 percent by the dairy herd (beef production derived as a co-product from surplus calves and culled cows) (FAO, 2013).

While ruminants play an important role in providing high quality protein essential for human diets, they are an important source of greenhouse gas (GHG) emissions (FAO, 2013). The GHG emissions report edited by FAO (2013) pointed out that globally about 4.255 million tons of CO_2-eq were emitted by the cattle sector; of this, 2.836 million tons were associated with beef production.

To avoid significant increases in total GHG emissions from the sector while coping with increasing demand for its products, a reduction of the intensity of emissions is required. The emission intensity (Ei) of a commodity, measured as the quantity of GHG emissions generated per unit of output, is a useful metric very closely linked to the efficiency of the system, measured in terms of output per animal, or on a whole herd basis. Average Ei for beef production was estimated at 46,2 kg CO_2-eq/kg CW (FAO, 2013).

The largest source of GHG emissions of ruminants is methane from enteric fermentation, which accounts for about 47% of the sector´s emissions and more than 90% of the total methane emissions. Nitrous oxide (N_2O) emissions originating mainly from feed production and N deposited during grazing represent 24% of the sector´s GHG emissions. Emissions from land-use change associated with the expansion of grassland into forest account for 14,8% of total emissions related to beef production (FAO, 2013).

2. Methane emissions from enteric fermentation

Methane is produced when organic materials decompose in oxygen-deprived conditions, notably from fermentative digestion by ruminant

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livestock, stored manures and rice grown under flooded conditions (Mosier et al., 1998). Net emissions in ruminants are influenced by feed intake and digestibility, while Ei is a function of net emission and yield per animal, which in turn are affected by health and genetics, among other factors. At herd level, factors affecting net emissions are similar to those cited above, while Ei is determined by issues such as reproductive and mortality rates, herd structure, management, etc. (Berndt & Tomkins, 2013).

Regions and production systems with greater productivity have lower methane Ei partly because high yields shift the distribution of energy in feed towards less energy for maintenance functions and more for production. As productivity per animal increases, methane emissions per animal are typically higher because of higher feed intake, however methane emission expressed as kg CO_2-eq/kg CW will be reduced.

In view of livestock's sizeable share of global greenhouse gas emissions, numerous technical options have been identified to mitigate these emissions. Feeding management and nutrition and, genetic/genomics are among the main studied mitigation strategies to reduce methane emissions from farm animals (Gerber et al., 2013).

2.1. Feeding management

Forage quality, feed processing and precision feeding have the best prospects among the various available feed and feed management measures (Gerber et al., 2013; Grainger & Beauchemin, 2011). Harvesting forage at an earlier stage of maturity increases its soluble carbohydrate content and reduces lignification of plant cell walls, thereby increasing its digestibility and decreasing enteric methane production per unit of digestible dry matter (Hart, Martin, Goley, Kenny, & Boland, 2009).

High-sugar grasses from temperate regions (grasses with elevated concentrations of water-soluble carbohydrates) have been investigated as a tool for mitigating the environmental impact of livestock. These forages may have some mitigation effect on N losses, but the prospect for reducing enteric methane emissions is uncertain. Archimede et al. (2011) showed that C4 grasses produce greater amount of enteric methane than C3 grasses, and recommended the use of legumes in warm climates as a mitigation option, as animals fed warm climate legumes produced 20% less methane than animals fed C4 grasses. De Ramus, Clement, Giampola, and Dickison (2003) demonstrated that management-intensive grazing offered a more efficient use of grazed forage crops and more efficient conversion of forage into meat, which resulted in a 22% reduction of projected methane annual emissions from beef cattle.

Hristov et al. (2013) concluded that inclusion of concentrate feeds in the diet of ruminants will likely decrease enteric methane, particularly when inclusions are above 35% to 40% of DMI. Small amounts of concentrate feeds will increase animal productivity and thus decrease GHG Ei, but if emissions from concentrate feed production are included, absolute GHG emissions may not always decrease (FAO, 2013).

Among the feed supplement options for lowering enteric emissions, dietary lipids, nitrate, ionophores and tannins are identified as effective but with variable productivity results among studies (Gerber et al., 2013). Hristov et al. (2013) proved that lipids are effective in reducing enteric methane emission, but the feasibility of this mitigation practice depends on affordability of oil products and potential negative effects on animal productivity if fibre digestibility is affected. Recent research (Hristov et al., 2013) has shown promising results with nitrates decreasing enteric methane emission up to 50%. Nitrates may be particularly attractive in subtropical developing countries where forages contain insufficient crude protein (CP) for sustaining animal production.

Working with grazing systems, Potter, Muller, Wray, Carrol, and Meyer (1986) concluded that ionospheres like monensin had strong anti-methanogenic effect in cattle, improving feed efficiency and lowering enteric methane Ei. However, ionophores are banned in the European Union, therefore they are not applicable everywhere.

Tannins as feed supplements or as tanniferous plants have often, but not always, shown potential for reducing enteric methane emissions, in some cases by up to 20% (Staerfl, Ziez, Kreuzer, & Soliva, 2012). However, the effects of tannin on animal digestion and productivity are variable among studies.

2.2. Cattle genetic improvement

Cattle genetic improvement for feed efficiency is an indirect approach for reducing enteric methane emissions in cattle. Selection for residual feed intake will result in cattle having less dry matter intake, improved feed conversion ratio and reduced enteric methane emissions at equal levels of production, body size and body fatness (Basarab et al., 2013).

2.3. Genome sequencing of rumen bacteria and archaea

Methanogens are the sole producers of ruminant methane and therefore methane abatement strategies can either target the methanogens themselves or target the other members of the rumen microbial community that produce substrates necessary for methanogenesis. Consequently, exploring the relationship that methanogens have with other rumen microbes is crucial when considering methane mitigation strategies for farmed ruminants (Leahy et al., 2013).

3. Methane emissions by production system and agro-ecological zone

Large variability exists in Ei intensities across regions and production systems. This variation is largely driven by differences in production goals (specialized versus non-specialized production) and management practices, including animal husbandry methods, animal health and genetics, which influence levels of productivity (FAO, 2013). On average, mixed systems (livestock production systems in which more than 10% of the dry matter fed to livestock comes from crop by-products and/or stubble) have slightly lower methane Ei than grassland-based ones. This difference could be explained by factors such as reproductive efficiency (higher fertility rates, lower age at calving), animal health (lower mortality rates), management (higher slaughter weights, reduced time to slaughter), and better feed. All these factors combine into higher productivity (Berndt & Tomkins, 2013).

Of all land uses, raising livestock now occupies the largest share. About 31,5 million km^2 of land (20 to 30% of the global surface), is at present exposed to grazing, and as much as a third of the cultivated land area (total area 15 million km^2) is used for feed and forage (Janzen, 2011.) According to FAO data (FAOSTAT, 2012), there are 1.485 million cattle distributed through the world. One third of global cattle stock is located in Asia, one third in America, one fifth in Africa and one tenth in Europe and Oceania (Table 1).

Among the top ten beef export countries of the world, five are located in Latin America: Brazil, Argentina, Uruguay, Paraguay and Mexico, which produce on extensive systems. As main beef exporters, they will try to increase their beef production in order to take advantage of the growing international markets in the near future. The five Latin-American countries, account in total 341 million cattle, which means a quarter of the global stock, and only two of them, Argentina and Uruguay, have most of their production based on temperate pastures (FAOSTAT, 2012).

In Latin America, beef contributes about 54% of the total protein from cattle, mainly because the emphasis is on beef rather than on dairy (FAO, 2013). In contrast industrialized regions grow cattle to produce meat and milk. In these regions, Ei is generally lower, because production is more efficient, with greater yields (Leip et al., 2010).

Highest Ei take place in such developing regions. The key drivers are low feed digestibility, lower harvest weights and higher age at harvest (Berndt & Tomkins, 2013). The carbon footprint of beef produced in Latin America also comprises emissions related to land-use change from pasture expansion into forested areas (Steinfeld & Wassenaar,