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The net contribution of ruminant production to the protein supply for humans

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Abstract

Total protein conversion efficiency of ruminant production systems is low (between 0.05 for meat and 0.25 for milk), but this calculation usually does not differentiate human-edible from human non-edible feedstuffs (e.g. grass, by-products of food and biofuels industries). To evaluate the net contribution of ruminant livestock to protein production for human consumption in France we estimated the human-edible protein Fraction (hepF) of the diets and the net protein efficiency (human-edible protein efficiency) from six contrasting feeding systems in dairy, beef cattle and sheep systems. The hepF values of diets ranged from 3% (extensive sheep production) up to 26% (intensive dairy cattle production). The net protein efficiency ranged from 0.34 (intensive sheep production) up to 2.57 for grass-based dairy cattle production with low concentrate consumption. Each type of ruminant production can produce more edible protein than they consume (net protein efficiency > 1). The use of grass and by-products are the key factors to improve the net contribution of ruminant production to protein supply for humans.

Keywords: protein efficiency, feed-food competition, dairy cattle, beef cattle, sheep, human-edible protein

Introduction

Ruminant production is perceived as less efficient and in competition with crops for the human food supply. It takes more than 3 kg of plant protein to produce one kg of milk protein and between 5 and 10 kg to produce one kg of bovine meat proteins (Peyraud and Peeters, 2016). This usual way to evaluate protein conversion efficiency does not differentiate human-edible from human non-edible feedstuffs (e.g. grass, by-products of food and biofuels industries) in livestock feeding. The feed/food competition only concerns those proteins of plant origin that are consumed by animals and that are consumable by human. The amount of edible protein of animal origin produced by kg of human-edible protein of plant origin used in animal feeding is an unbiased view of the contribution of livestock to protein production (Wilkinson, 2011; Ertl *et al.*, 2015). The aim of this work was to evaluate the potential of ruminant livestock for net production of protein for human consumption with a focus on contrasted French dairy cattle, beef cattle and sheep production systems.

Materials and methods

The total protein efficiency and the net protein efficiency at the production system level were calculated as follows:

Total protein efficiency = total protein output / total protein input

Net protein efficiency = human-edible protein output / human-edible protein input

With: output = all animal products; and input = all feeds consumed

The human-edible protein output includes all edible protein from the production system. Ninety eight percent of the milk sold by dairy cattle farms is human-edible and the edible fraction of animals (meat, edible offal and by-products) currently consumed in France represents 55, 60, 63 and 43% of total protein in slaughtered animals for dairy cow, beef cow, fattened young cattle and lamb respectively, Laisse *et al.* (2016).

The human-edible protein input includes all human-edible feed protein consumption of the production system. A table of human-edible protein fraction (hepF) of the main feedstuffs used in France was built from literature data and interviews with the food industry experts (Laisse *et al.*, 2016). For example, in the ‘current situation’ of food industry, hepF of wheat, maize grain, soybean meal and rapeseed or sunflower meal were estimated respectively at 66, 15, 60 and 0%. The hepF values of forages were estimated at 0%, except for maize silage which hepF was set at 10% to consider the grain fraction. A ‘potential scenario’ was built with increased values of hepF to take into account the progress in protein extraction from the food industry in the future (e.g. protein extraction from rapeseed meals) and the potential changes in eating habits (e.g. more consumption of wholemeal flours).

The total and the net protein efficiency were then calculated using data from real farms collected in the farm network surveys from INRA, IDELE and Chambres d’Agriculture (‘Inosys-Réseaux d’Elevage’). All calculations were made at the production system level taking into account all animals and all feed consumptions. Table 1 presents the main characteristics of the production systems studied.

Results and discussion

Total protein efficiency of ruminant production systems is low and varied between 0.05 (BC1) and 0.24 (DC1) (Figure 1). The hepF of the whole diets is also low and varied between 3% (Sh2) and 26% (DC1) for the ‘current scenario’. The net protein efficiency is much higher than the total protein efficiency and reached or exceeded a value of 1 for DC1 and DC2, BC2 and Sh2 (Figure 1). This means that all ruminant production systems have the potential to produce more human-edible protein than they consume and contribute positively to the production of protein for human nutrition.

Figure 1 reveals large variation in net protein efficiency within each type of ruminant production. Grass-based dairy cow systems with low consumption of concentrates (DC2) can produce 2.5 times more human-edible protein than they consume. For beef cattle systems, cow-calf fattening systems can produce as much or more human-edible protein than they consume, provided they use low amount of maize silage and soybean meal (BC2). Sheep production systems with 1 lambing year⁻¹, high consumption of grass

Table 1. Animal performances and diet composition of the livestock systems studied.

Production system characteristics			Diet composition (% of total dry matter consumed)							
Type of production	Animal	Concentrate	Maize	Grass	Cereal	Cereals by-	Soybean	Other	Other	
	productivity ¹	consumption	silage	forages	grains	products	meal	meals	feedstuffs	
Dairy cattle	DC1	8,490 l cow ⁻¹	1,480 kg LU ⁻¹	42.4	38.6	7.7	1.2	6.2	2.9	1.0
	DC2	5,745 l cow ⁻¹	603 kg LU ⁻¹	0.0	90.0	7.7	1.0	0.1	0.2	1.0
Beef cattle	BC1	400 kg LU ⁻¹	776 kg LU ⁻¹	7.0	73.0	4.0	4.0	8.0	2.0	2.0
	BC2	453 kg LU ⁻¹	763 kg LU ⁻¹	4.0	78.0	4.0	5.0	5.0	1.0	3.0
Sheep	Sh1	1.83 lamb ewe ⁻¹	148 kg ewe ⁻¹	0.0	87.0	5.3	3.3	1.9	0.7	1.8
	Sh2	1.51 lamb ewe ⁻¹	48 kg ewe ⁻¹	0.0	96.2	1.4	0.8	0.5	0.2	0.9

¹ l cow⁻¹ = annual milk production per cow; kg LU⁻¹ = live weight produced per livestock unit (LU), more than 90% of the live weight produced is fattened and slaughtered; lamb ewe⁻¹ = ewes > 12 months.

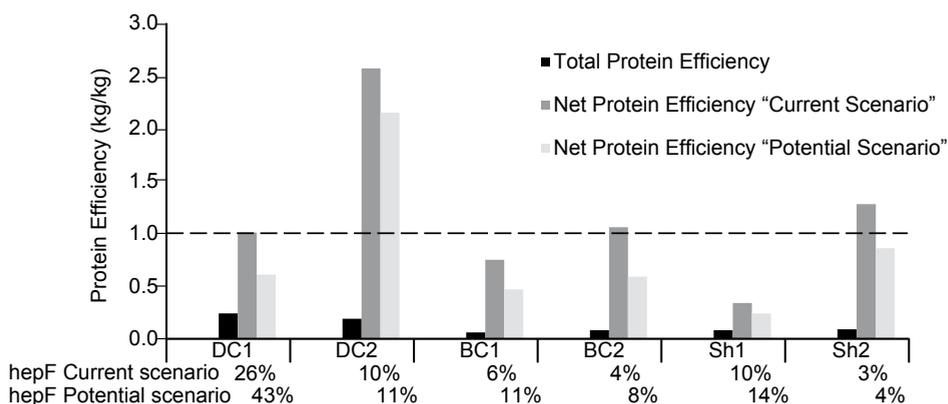


Figure 1. Total and net protein efficiency of the ruminant livestock systems described in Table 1, according to the human-edible fraction of the diet (hepF) for current and potential scenarios.

and very low consumption of concentrates (Sh2) can also be net producer of protein compared to more intensive systems with 3 lambing per 2 years and higher concentrate consumption (Sh1).

With the 'potential scenario' of protein use for food, net protein efficiency of all production systems decreases. Grass-based dairy system remains a net protein producer. This clearly shows the interest of grass and non-edible by-products to improve the net protein efficiency of ruminant production systems. By taking into account the higher nutritional value of animal proteins for humans, a net protein efficiency of 0.8 would be sufficient to at least maintain a neutral contribution of ruminant productions to the protein supply for humans (Peyraud and Peeters, 2016).

Conclusion

The calculation of net protein efficiency, taking into account the human-edible part in feed consumption, shows that dairy cattle but also beef cattle and sheep production can positively contribute to the protein supply for humans. The use of grass and non-edible by-products are the key factors to improve the net protein efficiency of ruminant productions.

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