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Protein conversion efficiency in French dairy small ruminant systems

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Abstract. Dairy production is facing social issues due to competition in the use of resources (feeds, water and land). The French livestock Institute (Idele) has characterized feed conversion efficiency for the dairy small ruminants in France. DIAPASON database from a reference farms' network (INOSYS-Réseaux d'élevage) has been used to determine the efficiency of a large number of dairy systems in France between 2012 and 2016. Systems studied in this reference network are on average net producers of proteins: 52% for dairy sheep and almost 50% for dairy goats. Diet composition is of critical importance. Cereals are directly in competition with human nutrition while grass as pasture or silage are not, giving a positive impact on efficiency. This is why we show that grass-based dairy systems, specifically those with pasture, are very efficient to turn proteins from grass into high-quality proteins for human nutrition. A high variability within and between systems and species is shown and gives the opportunity to propose technical ways to improve this new approach on farm.

Keywords. Dairy systems – Feed conversion efficiency – Goat – Sheep – Competition feed/food.

L'efficience de conversion des protéines dans les systèmes français de petits ruminants laitiers

Résumé. *L'élevage et la production d'animaux laitiers font face aujourd'hui à des problèmes de société dus à la compétition dans l'utilisation des ressources (alimentation des animaux, eau et utilisation des terres). L'Institut de l'Elevage (Idele) a caractérisé l'effcience de conversion alimentaire des élevages de petits ruminants laitiers, les brebis et les chèvres laitières. La base de données DIAPASON, issue de la collecte dans un réseau de fermes de référence (Inosys-Réseaux d'élevage), a été utilisée pour déterminer l'efficience d'un grand nombre de systèmes laitiers français entre 2012 et 2016. Les systèmes étudiés dans ce réseau de référence sont en moyenne producteurs nets de protéines : 52% pour les ovins laitiers et quasiment 50% pour les chèvres laitières. La composition de la ration a une importance cruciale. Les céréales sont directement en compétition avec l'alimentation humaine tandis que l'herbe, en pâturage, foin ou ensilage, ne l'est pas et a donc un impact positif sur l'efficience. C'est pourquoi nous avons pu montrer que les systèmes laitiers basés sur l'herbe, en particulier ceux basés sur le pâturage, sont très efficaces pour convertir les protéines de l'herbe en des protéines de haute qualité pour la nutrition humaine. Une grande variabilité existe en intra– et en inter-systèmes, mais aussi entre les espèces, ce qui nous donne l'opportunité de proposer des voies techniques pour approfondir et améliorer l'utilisation cette nouvelle approche en élevage.*

Mots-clés. *Systèmes laitiers – Efficience de conversion alimentaire – Chèvres – Brebis – Niveau de compétition.*

I – Introduction

Dairy production is facing social issues due to competition in the use of resources (feeds, water and land). Ruminants are often characterized as non-efficient because they consume around 3 kg of plant proteins to produce 1 kg of milk (Peyraud and Peeters, 2016). But the truth is more nuanced. This approach does not take into account that ruminants (i) have the ability to value non-human edible resources such as grass and by-products, (ii) release high quality products with high nutritional values. In addition, animal husbandry has positive externalities beyond food production, like landscape and biodiversity conservation or storage of carbon (Hoffmann *et al.*, 2014). So a new approach has been proposed dealing with the evaluation of human-edible from human non-edi-

ble feedstuffs in livestock feeding strategies. Some results using this new criteria are already available in the literature for different feeding systems in different countries (Wilkinson, 2011; Ertl *et al*., 2015). The objective of our study is to determine the conversion efficiency –for both energy and proteins– of a large number of dairy systems in France for goat and sheep production.

II – Materials and methods

1. Data collection

DIAPASON database from a reference farms' network (INOSYS-Réseaux d'élevage) has been used for a large number of dairy systems in France between 2012 and 2016. This network lasts since more than 30 years and allows the collection of various and numerous data routinely on more than 1,000 farms. The total intake for both roughages and concentrates has been registered: inventory changes for all feeds except for pasture (estimation). The total meat and milk production has also been collected. Over the 5 years of the database used for this study, missing and uncoherent data have been deleted leading to 847 data from 274 farms for dairy goats and 343 data from 108 farms for dairy ewes.

The first step has been to use and complete an existing table of human-edible energy and protein fractions of the main feedstuffs used in France (Laisse *et al*., 2016). For example, the human-edible protein fraction is 66% for wheat whereas it is 0% for rapeseed or sunflower meals. For roughages, this fraction is estimated to 0%, except for maize silage (10%) to consider the grain fraction. Almost a hundred of feeds have been characterised, as shown in Table 1 (few examples).

Table 1. Proportion of human-edible protein in some feeds from dairy ruminants' ration

Type of feed	Feed	Proportion of human-edible protein (%)
Forage	Pasture	0
Forage	Maize silage	10
Forage	Hay	0
Forage	Non mature cereals silage	70
Concentrate	Wheat	66
Concentrate	Faba bean	92
Concentrate	Soybean meal	60
Concentrate	Canola meal	0
Concentrate	Industrial concentrate (22% protein)	46
Concentrate	Beet pulp	0

2. Calculation

The second step is the calculation of 2 ratios to estimate the efficiency for protein (kg of crude protein/kg of feed and animal products). The total efficiency considers the ratio between the total outputs (meat and milk production) and inputs (feedstuffs intake) while the net efficiency considers only human-edible fractions of inputs. All calculations are made at the farm level, including both intake and production for all types of animals (young and adults for meat and milk).

III – Results

1. Part of proteins consumed by goats (G) and sheep (S) that are not consumable by humans

Food systems in goat farming are defined within the framework of the Observatory of the feeding of dairy goats (Bossis and Jost, 2016): 9 feed systems are defined, according to the nature and the quantity of the fodder used in the ration of the goats. In France, fodder constitutes on average 68% of the goats' diet. The grass, green or preserved, represents 65% of the goats' ration and hay is present in the ration of almost all the goats (50% of the ration). This share varies according to the region, depending on climatic conditions and soil potential. Concentrates make up an average of 32% of goats' diet. They are produced on average at 23% on the farm. The average annual consumption of goat herd concentrates in France is 383 kg DM per goat: 43% of the food is raw seeds (cereals and oil-protein crops), 39% are compound feeds with high levels of competition and 13% of concentrated feeds are by-products with low levels of competition.

Food systems in sheep farming are defined within the framework of the Observatory Inosys-Réseaux délevage. We only consider in this study farms that are delivering milk (i.e not on-farm cheese producers). Within those farms, 11 systems are defined but to make it more simple, 5 groups have been defined, depending only on geographical area and practice of transhumance. In France, sheep feeding is mainly based on conditions to obtain the PDO labels. For forages, to produce Roquefort ewes have to receive 1 kg DM of hay per day and grazing is mandatory every day when meteorological conditions are good enough. To produce Ossau-Iraty, ewes have to graze 240 days minimum per campaign and silage is forbidden during milking period. For concentrates, it is limited to 800 g per day and per ewe for the Ossau-Iraty PDO.

On average, 83% (G) and 88% (S) of the proteins consumed by goats and sheep cannot be consumed by humans. Only 17% (G) and 12% (S) of proteins are human-edible food.

2. Part of goat and sheep farms that are net producers of protein for human consumption

Almost 50% of goat farms and 52% of sheep farms are net producers of protein for human consumption.

Total protein efficiencies are on average 0.15 (G) and 0.13 (S). This indicator is not very variable between feed systems (Table 2), in relation with the share of fodder (G+S) and the level of milk production (G). It takes 6.7 kg (G) and 7.7 kg (S) of vegetable protein to produce 1 kg of animal protein.

The net efficiencies for protein are 1.14 (G) and 1.16 (S). Goat and sheep sectors are therefore on average net producer of proteins for human consumption. For both productions, it then takes 0.9 kg of protein from vegetables that could be eaten by humans to produce 1 kg of animal protein.

The mean values, however, hide a variability within the sample, with high net efficiencies for protein standard deviation of 0.86 (G) and 0.55 (S). Only 43% of goat farms and 52% of sheep farms are net producers of protein for human consumption. Nevertheless, the margins of manoeuvre exist since 65% (G) and 71% (S) of farms have a net protein efficiency level higher than 0.8. This means that 20% of French goat and sheep farms are close to equilibrium (net efficiciency value = 1).

Table 2. Total and net protein utilisation of food resources for some dairy goat and sheep systems

Feed system (G: goat, S: sheep)	Part of protein consumed by animals that can not be consumed by humans (%)	Total protein efficiency	Net protein efficiency	Part of the system at the national level (%)
Average (G) n=847	**83**	**0.15**	**1.14**	
Pastoral (G) n=191	88	0.13	1.54	20
Legumes hay (G) n=135	81	0.16	0.93	19
Pasture (G) n=208	85	0.15	1.08	18
Maize silage (G) n=81	79	0.18	0.74	10
Average (S) n=343	**88**	**0.13**	**1.16**	
Corsica (S) n=33	92	0.10	1.38	7.7
Pyrénées-Atlantiques, transhumant (S) n=54	91	0.10	1.28	34.7
Roquefort area, pastoral (S) n=84	88	0.14	1.02	24.3

Source: DIAPASON.

IV – Conclusion

Protein feed conversion efficiency is a critical issue for the future for ruminant production, as it is part of the competition between feed and food uses. For the future, more issues have to be addressed on this database like land use ratio to estimate land use efficiency of livestock systems (van Zanten *et al*., 2016) and animal protein quality for human nutrition. Energy feed conversion efficiency will also be studied. Another step of this project deals with a better understanding of the variability of these indicators, with technical factors. The variations in net efficiency can be explained mainly by (i) the level of grass in the diet, (ii) the ratio between milk production and the amount of concentrates and (iii) forage quality.

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