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Abstract. In France, the aim of sustainable goat farming systems is to use more forages as a tool to increase feed self-sufficiency and to produce cheeses of high value. Thus, it is worthwhile to check the factors of variation of feed efficiency in dairy goats fed barn-dried hay produced in a system including pastures. Twenty-two mid-lactating dairy goats (11 Alpine and 11 Saanen) received *ad libitum* barn-dried hay obtained from fields at Inra Lusignan and a concentrate separately with a forage/concentrate ratio 55/45. Dry matter intake (DMI) expressed on a body-weight basis was higher for Alpine than for Saanen. Organic matter digestibility was not influenced by level of intake and was mainly function of indigestible cell wall. Fat and protein corrected milk yield (FPCMY) was directly proportional to digestible organic matter intake (DOMI). Feed efficiency (1.38 ± 0.137) or ratio of FPCMY/DMI is the product of the digestive efficiency (DOMI/DMI) by the metabolic efficiency (FPCMY/DOMI). It was mainly correlated to metabolic efficiency (r = 0.97), but not to digestive efficiency, probably due to its low range of relative variation. It increased with the level of milk production and tended to be higher for Saanen than for Alpine goats when milk production was used as a covariate. Moreover, the ratio "N output in milk/N intake" with the tested diet was directly proportional to feed and metabolic efficiencies. Thus, in our context, high producing animals have a better feed efficiency.

Keywords. Feed efficiency – Barn-dried hay – Dairy goat.

Etude de l'efficacité alimentaire du foin ventilé obtenu dans un système durable (Patuchev) pour des chèvres laitières

Résumé. *En France, l'objectif des systèmes de production durables est de maximiser l'utilisation des fourrages comme moyen d'améliorer l'autonomie alimentaire et de produire des fromages à haute valeur ajoutée. Il est donc important de quantifier les facteurs de variation de l'efficacité alimentaire du foin ventilé produit dans un système incluant du pâturage et distribué à des chèvres laitières. Vingt-deux chèvres (11 Alpine et 11 Saanen) ont reçu, en quantité ad libitum, du foin ventilé cultivé à l'Inra de Lusignan et séparément de l'aliment concentré avec un ratio fourrage/concentré de 55/45. Les chèvres de race Alpine ont ingéré plus de matière sèche (MSI rapportée au poids vif) que les Saanen. Le niveau d'ingestion n'a pas influencé la digestibilité de la matière organique qui était essentiellement fonction de la teneur en paroi indigestible. La production laitière standard (PLS, corrigée par les taux butyreux et protéique) a été directement proportionnelle à la quantité de matière organique digestible ingérée (MODI). L'efficacité alimentaire (1,38 ± 0,137) ou rapport PLS/MSI est égal au produit de l'efficacité digestive (MODI/MSI) par l'efficacité métabolique (PLS/MODI). Elle est principalement liée à l'efficacité métabolique (r = 0,97), mais pas à l'efficacité digestive, probablement due à la faible variation relative de cette dernière. L'efficacité alimentaire a augmenté avec le niveau de production laitière et a été numériquement plus élevée pour les Saanen que pour les Alpine quand la production laitière est prise en compte. De plus, le ratio « N excrété dans le lait/ N ingéré » était directement proportionnel aux efficacités alimentaire et métabolique. Ainsi, dans le contexte présent, les animaux à haut niveau de production ont une meilleure efficacité alimentaire.*

Mots-clés. *Efficacité alimentaire – Foin ventilé – Chèvre laitière.*

I – Introduction

Feeding barn-dried hay to dairy goats is one option to improve sustainability of goat farming system as a tool to increase self-sufficiency and to produce cheeses of high sale value, especially in France that is the leading goat cheese producer in Europe (ANICAP (Association Nationale Interprofessionnelle Caprine), 2017). The aim of this work is to check the factors of variation of feed efficiency in dairy goats fed a diet containing barn-dried hay from grazed and mown grasslands and concentrate to fulfil their requirements. Goats were from the two predominant breeds in France: Alpine and Saanen (Idele (Institut de l'Elevage), 2018).

II – Material and methods

The present study was handled in accordance with the French legislation on animal experimentation and European Convention for the Protection of Vertebrates used for Experimental and other Scientific Purposes (European Directive 86/609). The protocol was approved by the ethical local committee (Comité d'Ethique en Expérimentation Animale, COMETHEA 45) and was registered as 15-79.

Twenty-two dairy goats were allotted in two groups according to their breed: 11 Alpine (A) and 11 Saanen (S). Six goats were in second lactation (3A and 3S), six on third lactation (2A and 4S) and another six, in fourth lactation (3A and 3S) and the remaining four in fifth lactation (3A and 1S). They were in mid-lactation at the beginning of the trial (81 ± 3.1 Days in Milk) and milked twice a day around 7 am and 3 pm. They were fed *ad libitum* barn-dried hay (at least 15 % refusals) twice a day: two thirds of hay were delivered after the afternoon milking and one third after the morning milking according to the intervals between milkings. This hay was produced from multi-species grasslands of the experimental platform Patuchev (UE FERLus-Inra Lusignan). Grasslands were composed of fescue, brome, Italian rye-grass, alfalfa, white and red clovers. Goats received separately a commercial concentrate (Fluvialac®) in 4 meals (one third after each milking and one sixth at the end of the morning (around 11 am) and at the end of the afternoon (around 5 pm). The quantity of concentrate was adapted to each goat to obtain a forage/concentrate ratio of 55/45 on a dry matter basis.

Goats were housed in individual crates during the 9-weeks trial. Six Alpine and six Saanen were moved to one of the 12 digestibility crates (Giger and Hervieu, 1980) after five weeks of adaptation and the ten remaining (5A and 5S) after seven weeks because only twelve crates were available. Digestibility measurements were performed during a five days period after one week of adaptation to the digestibility crates. Body weight was measured before the period in digestibility crates around 2 p.m.

The dry matter (DM) and ash contents of feeds, refusals and faeces were determined according to ISO methods (ISO, 1978; ISO, 1983). Total N was determined by the Dumas technique (Sweeney and Rexroad, 1987). The NDF (or cell wall) content was estimated by the method of Van Soest and Wine (1967) modified by Giger *et al.* (1987) with the use of a heat stable α-amylase but without sodium sulphite and decalin. Fat and protein contents of milk were analysed by infrared spectrophotometry (labo Uriane, La Capelle, Aisne, France). Milk yield was corrected for fat and protein contents (Sauvant and Giger Reverdin, 2018).

Breed effect was tested by an ANOVA procedure on the mean values per goat.

III – Results and discussion

1. Intake and milk yield

Dry matter intake (DMI) during the digestibility trial period was higher for Alpine goats than for Saanen goats expressed in kg/d or in g/kg body weight/d (Table 1). N intake per day was also higher for Alpine compared to Saanen, such as raw milk yield. Fat and Protein corrected milk yield (FPCMY) only tended to be higher for Alpine goats due to a lower numerical value for fat content compared to Saanen.

Table 1. Breed effect on body weight, intake, milk yield and composition (n= 11 goats per breed)

	Alpine	Saanen	P value
Intake and body weight			
Body weight (kg)	62.6 (± 6.36)	65.7 (± 4.66)	0.20
DMI (kg/d)	3.31 (± 0.233)	3.02 (± 0.222)	0.01
DMI (g/kg of BW per day)	53.2 (± 4.74)	46.1 (± 4.19)	0.001
N intake (g per day)	93.9 (± 8.00)	84.7 (± 7.00)	0.009
Milk yield and composition			
Raw milk yield (kg/d)	4.42 (± 0.352)	3.96 (± 0.514)	0.03
Fat	36.6 (± 3.11)	38.1 (± 6.15)	0.47
Protein	32.3 (± 3.09)	31.7 (± 2.09)	0.66
Fat and Protein corrected milk yield (kg/d)	4.56 (± 0.358)	4.16 (± 0.636)	0.09

2. Digestibility and feed efficiency

Organic matter, cell wall (NDF) and crude protein digestibilities were similar for the two breeds (Table 2). Organic matter digestibility of the diet was not influenced by the level of intake, but it was mainly function of the indigestible part of the cell wall measured for each goat ($r = 0.88$, $n = 22$, RSD = 0.785, $P < 0.01$) in agreement with the Inra 2018 system (Baumont *et al.*, 2018). Corrected milk yield was directly proportional to the digestible organic matter intake (DOMI):

Corrected milk yield = 2.24 (± 0.047) (DOMI kg/d) ($r= 0.61$, $n = 22$, RSD =0.440 kg/d, $P < 0.01$)

Feed efficiency was calculated as the ratio of FPCMY on DMI expressed in kg/d (Arndt *et al.*, 2015). Thus, it is also the product of the ratio of DOMI/DMI (digestive efficiency) by the ratio FPCMY/DOMI (metabolic efficiency). There is no breed effect for all the efficiencies (Table 2).

Feed efficiency was mainly correlated to metabolic efficiency:

Feed efficiency = 0.614 (± 0.0033) Metabolic efficiency ($r = 0.97$, $n = 22$, RSD = 0.0348, $P <0,01$)

Feed efficiency was not correlated with digestive efficiency ($r = 0.12$, $n = 22$, $P = 0.58$). This was probably due to the low range of relative variation of digestive efficiency (2.55 %) compared to metabolic (9.89 %) or feed efficiency ‘9.93 %). Feed efficiency increased linearly with the level of FPCMY and was numerically higher for Saanen than for Alpine goats when FPCMY was used as a covariate ($P=0.052$). It must also be stressed that the ratio “N output in milk/N intake” was directly proportional to feed efficiency ($r = 0.75$, $n = 22$, $P < 0.01$) and to metabolic efficiency ($r = 0.66$, $n = 22$, $P < 0.01$) and not correlated to digestive efficiency ($r = 0.33$, $n = 22$, $P = 0.14$).

Table 2. Breed effect on digestibility and feed efficiency (n= 11 goats per breed)

	Alpine	Saanen	P value
Digestibility			
Organic matter (%)	67.7 (± 1.49)	67.1 (± 1.66)	0.36
Cellwall or NDF (%)	54.1 (± 5.50)	52.4 (± 4.17)	0.42
Crude protein (%)	68.7 (± 1.69)	67.5 (± 2.48)	0.19
Efficiency			
Feed efficiency	1.38 (± 0.098)	1.38 (± 0.172)	0.98
Digestive efficiency	0.617 (± 0.0160)	0.612 (± 0.0158)	0.48
Metabolic efficiency	2.24 (± 0.169)	2.25 (± 0.274)	0.89

IV – Conclusion

High producing animals have better feed efficiency than low producing ones with barn-dried hay obtained in a sustainable goat farming system, and the difference between breeds in intake has no influence on feeding efficiency.

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