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Dominique Pomiès, Bruno Martin, Philippe Pradel, Isabelle Verdier-Metz, Isabelle Constant, Céline Delbès-Paus, Olivier Troquier, Florence Fournier, Marie-Christine M.-C. Montel, Anne A. Farruggia

Pastoralism and ecosystem conservation

Proceedings of the 17th Meeting of the FAO-CIHEAM Mountain Pasture Network

5-7 June 2013, Trivero, Italy

http://fao13.adcf.ch/

Edited by
DISAFA – Department of Agricultural, Forest and Food Sciences
University of Turin, Italy

Design of low-input dairy farming systems in mountain areas: animal performances and cheese sensory properties

Pomiès D.[1,2*], Martin B.[1,2], Pradel P.[3], Verdier-Metz I.[4], Constant I.[1,2], Delbès-Paus C.[4], Troquier O.[3], Fournier F.[3], Montel M.C.[4], Farruggia A.[1,2]

[1]INRA, UMR1213 Herbivores, F-63122 Saint-Genès-Champanelle, France
[2]Clermont Université, VetAgro Sup, UMR1213 Herbivores, BP 10448, F-63000 Clermont-Ferrand, France
[3]INRA, UE1296 Monts d'Auvergne, F-63210 Orcival, France
[4]INRA, UR545 Fromagères, 20 côte de Reyne, F-15000 Aurillac, France
*E-mail: dominique.pomies@clermont.inra.fr

Abstract

Two experimental dairy farming systems were designed with the objectives of limiting the inputs and reinforcing the link to terroir in PDO cheese mountain areas. After 2 years, the functioning of the systems is not yet stabilized but they both produced interesting quantities of milk, although its composition was sometime not optimal for cheese manufacturing. Nevertheless, the poor reproduction results of the two systems must be corrected to ensure the renewal of the herds and their sustainability.
Keywords: low-input farming system, dairy cow, PDO cheese

Introduction

Milk produced in the French mountains is mainly transformed into PDO cheeses. PDO specifications aim at reinforcing the link to terroir, in particular by maximizing the use of local forages. In this context, two "contrasting" innovative dairy farming systems were designed with the objectives of limiting the inputs thanks to an optimal use of grasslands, and being sustainable.
This type of long term farming system research seems indeed the most adapted to improve our understanding of the interactions between management practices and animal performances at farm level, as suggested by Gibon et al. (1999).

Material and methods

The two systems are tested for 5 years, from April 2011, in an experimental farm of INRA located in an upland area of central France (1 100 m asl). Herd and lands were divided in two farmlets:

- **Bota** (French acronym for Biodiversity, Sensory, Work, Autonomy), 59.6 ha of diversified grasslands, with low stocking rate (0.66 LU/ha the 1st year), spring calving of 3-year-old cows, no mineral fertilization, no concentrates, long grassland rotation duration and long dry period for cows,
- **Pépi** (for Production, Efficiency, Planet, Innovation), 29.2 ha of permanent and old temporary grasslands, with moderate stocking rate (1.1 LU/ha the 1st year, which is slightly higher than average in the surrounding area), spring calving with 2-year-old cows, sharp adjustment of mineral fertilization and concentrates (4 kg/d at pasture), rotational grazing and early cutting.

Two groups of 24 similar cows and heifers have been paired at the beginning of the experiment and put on each system. The characteristics of the two herds are summarized in Table 1.
Strategies and decision rules for managing animals and land were established for each system, with the aim of producing most of the milk from pasture. A breeding season of 70 d (42 d for artificial insemination followed by 28 d for natural mating with a Limousin bull) has been scheduled for a very short calving period around the end of April, the time at which cows are usually put out to pasture. The renewal of each herd is made only of female calves born from it.
Measurements include forage production, inputs (fertilization and concentrates for Pépi), floristic diversity (in 2011) and animal performances. Animal performances are calculated from individual data: milk production at each milking, fat and protein contents two days a week on 4 consecutive milkings, live weight

at calving and twice a month, body condition score (**BCS**) at calving and every month, health events (mastitis, lameness, etc.) and reproduction data (heat, insemination, calving).
In 2012, cheeses have been manufactured with the milk produced by the not extended lactation cows of each system (see Results). Twelve Cantal cheeses have been made in controlled conditions with unskimmed raw and pasteurized milk in July when cows were on pasture. The sensory characteristics of the 5 months ripened cheeses were assessed by a trained panel.

Table 1: Characteristics of Bota and Pépi herds at the beginning of the experiment (spring 2011)

	Bota		**Pépi**	
Breed	Holstein	Montbéliarde	Holstein	Montbéliarde
Number of cows	12	12	12	12
% of primiparous	16.7	25.0	25.0	25.0
Rank of lactation at calving	2.9 ± 1.7	2.9 ± 1.8	2.7 ± 1.4	3.0 ± 1.8
Two-year-old heifers	4	5	-	-
One-year-old heifer	5	4	5	4

Results and discussion

Health

The main problems encountered the 1st year were calving fever and grass tetany on cows in April-May, when cows were turned out to pasture just after calving. They were linked to a nutritional deficit in Mg and they were resolved the 2nd year by a supplementation of MgCl powder put on the hay during April (100 g/d), plus a bolus of Mg for cows that had to calve at pasture. Lameness was also an important health problem (Table 2), especially at the end of summer when cows grazed far from the milking parlor. In 2012, for the Bota system, we reduced walking by grazing 2 plots each day: a distant one during the day and a closer one at night. On average, 26% of the cows had at least one mastitis, but Montbéliarde cows from the Bota system were very little subject to mastitis.

Table 2: Number of dairy cows from Bota and Pépi herds affected by lameness or mastitis

		Bota		**Pépi**	
Breed		Holstein	Montbéliarde	Holstein	Montbéliarde
Lameness	2011/2012	4	7	2	5
	2012/2013	6	5	2	4
Mastitis	2011/2012	6	0	3	5
	2012/2013	4	1	4	2

Reproduction and renewal

The 1st year, the performances of reproduction of the cows from the two farmlets were poor, especially for the Bota system (Table 3). In order to maintain 24 lactating cows in each system the following year, we extended the lactation of 9 cows from Bota and 7 from Pépi to about 20 months. In addition, this improved the reproductive performances during the 2nd year, because cows with long lactations reproduced better. Nevertheless, for the 3rd year, we will still have to prolong the lactation of 2 cows from Bota and 5 from Pépi. In the future we also have to use a methodology to improve reproductive performance, such as that described by Gouttenoire et al. (2010) for close experimental systems.

Table 3: Percentage of pregnant females in Bota and Pépi herds, at the end of the breeding season (confirmed by echography)

		Bota		Pépi	
Breed		Holstein	Montbéliarde	Holstein	Montbéliarde
2011	cows	33%	25%	50%	42%
	heifers	100%	80%	60%	75%
2012	cows after calving	38%	71%	44%	13%
	extended lactation cows	75%	80%	67%	75%
	heifers	100%	75%	80%	100%

Milk production and composition

During the first year (from 1st April 2011 to 31 March 2012), the cows from the Bota and Pépi farmlets produced 115 800 and 125 400 kg milk, the difference between the two systems being essentially due to Holstein cows (Table 4). During the 2nd year (from 1st April 2012 to 31 March 2013), the overall milk production of the two farmlets decreased by 22% (-16% in Pépi and -28% in Bota). This decrease is primarily related to the high percentage of cows in extended lactation (33% on average), that contributed to only 24% of the bulk milk. Over the two years, the difference between Pépi and Bota systems was about 375 kg/yr for Montbéliarde cows and 883 kg/yr for Holstein cows. This suggests that the Holstein breed is better adapted than the Montbéliarde one to produce milk in the Pépi system. But, as pointed out by Blanc et al. (2006), this ability to maintain a good production level can be antagonistic with the reproductive efficiency and the sustainability of the system.

Table 4: Milk production of Bota and Pépi herds, by year (1st April to 31 March) and by breed

		Bota		Pépi	
	(in kg)	Holstein	Montbéliarde	Holstein	Montbéliarde
2011	primiparous	9 950	13 210	15 070	14 160
	multiparous	51 900	40 740	53 340	42 790
2012	extended lactation cows	8 970	13 220	16 190	9 510
	primiparous	17 360	12 590	32 760	21 920
	multiparous	19 600	11 490	11 510	11 710
	2013 advanced calvings	-	130	100	280
Two years		107 780	91 380	128 970	100 370

The average milk fat and protein contents from the Bota and Pépi systems over the 2 years are presented in Table 5. As expected, the fat content is lower and the protein content higher in Pépi, linked to the concentrate supplementation. In 2012, fat and protein contents would have been lower than in 2011 if extended lactation cows which produced a very "concentrated" milk were excluded. For the Bota system, milk of the latter cows particularly helped to avoid the protein content to fall below 30 g/kg from mid-June to end of August, as in 2011.

Table 5: Milk composition of Bota and Pépi herds, by year (1st April to 31 March)

		Bota		Pépi	
Contents	*(in g/kg)*	Fat	Protein	Fat	Protein
2011	total herd	39.7	31.2	38.5	32.5
2012	total herd	41.8	32.9	37.7	33.3
	without extended lactation cows	40.2	30.7	37.0	31.9
	extended lactation cows	45.4	38.5	39.8	38.1
Two years		40.6	31.9	38.1	32.8

Concentrate feeding

The main difference between the two systems is that cows from Bota received no concentrate during the 2 years meanwhile, in accordance with the protocol, cows from Pépi received on average 4 kg/d of concentrate from calving to the end of the pasture season. This corresponded to 879 kg/yr of concentrate (1/3 wheat, 1/3 barley, 1/3 maize), with no difference between primiparous/multiparous or years. However, the Holstein cows received significantly more concentrate than the Montbéliarde cows (+102 kg/yr; $P<0.01$), due to their lower BCS and higher milk production. Holstein cows seem to have used more efficiently the concentrate in relation to the quantity of milk produced (175 *vs.* 212 g concentrates/kg milk; $P<0.05$). This result confirms that the Holstein breed seems to be better adapted than the Montbéliarde one to produce milk in the Pépi system.

Cheeses characteristics

Bota milk yielded in average +0.2 kg ripened cheese /100 kg milk in comparison to Pépi milk (Table 6). This slightly higher yield is linked to the higher fat content of Bota milk compared to Pépi milk (38.0 *vs.* 34.2 g/kg) which offsets its lower protein content (28.0 *vs.* 29.3 g/kg). In comparison to Bota cheeses, Pépi cheeses had a yellower coloration certainly linked to the leafy grass grazed in Pépi that could lead to a higher β-carotene content of grass and cheeses. Bota cheeses were characterized by a less firm and more melting texture certainly related to the higher fat in dry matter consecutive to the higher fat to protein ratio of Bota milk. In comparison to Pépi cheeses, the odour of Bota cheeses made with raw milk was described as more intense and characterized as more "fermented cream" and "yeast". The odour differences between Bota and Pépi cheeses were much lower and non significant when milk was pasteurized prior to cheesemaking. Similar interactions have already been reported in the literature (Martin et al., 2005) but, in this case, further chemical and microbial analyzes are required to understand the origin of the odour differences.

Table 6: Chemical and sensory characteristics of the 5 month ripened Cantal cheeses made in July 2012 with the bulk milk from the Bota and Pépi cows (extended lactation cows excluded)

	Bota		**Pépi**	
Milk treatment	Raw milk	Pasteurized milk	Raw milk	Pasteurized milk
Cheese yield (%)	8.6 ± *0.16*	8.4 ± *0.16*	8.3 ± *0.44*	7.9 ± *0.30*
Dry Matter (%)	63.6 ± *0.97*	63.6 ± *0.31*	63.6 ± *0.49*	64.4 ± *0.85*
Fat in Dry (%)	55.7 ± *1.35*	54.0 ± *0.80*	51.0 ± *1.04*	50.0 ± *0.78*
pH	5.56 ± *0.08*	5.36 ± *0.10*	5.60 ± *0.01*	5.47 ± *0.10*
Sensory descriptors (0-10)				
Yellow color	5.6 ± *1.00*	6.4 ± *1.12*	6.2 ± *1.08*	6.7 ± *0.97*
Firm Texture	4.6 ± *1.14*	5.8 ± *0.99*	5.0 ± *1.08*	5.8 ± *1.05*
Melting Texture	5.1 ± *1.47*	4.7 ± *1.17*	4.8 ± *1.24*	4.2 ± *1.38*
Intense Odour	6.2 ± *1.06*	5.1 ± *1.25*	5.6 ± *1.45*	4.9 ± *1.30*
Fermented Cream Odour	1.7 ± *1.50*	0.8 ± *1.02*	1.4 ± *1.37*	0.9 ± *1.11*

In conclusion, these first results show the feasibility of low input farming systems in mountain areas, where the milk produced is devoted to the manufacture of high quality cheeses. The sustainability of these systems shall nevertheless be assessed taking into account the low reproductive performances of the cows during the first experimental year. Other solutions to improve reproduction and renewal will be implemented: the advancement of the calving period, the use of sexed semen and the practice of once-a-day milking at calving for selected cows. In addition, these results confirm that the pasteurisation of the milk prior cheese making disrupt partly the link to terroir.

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