

Grass feeding: a cornerstone of the "One Quality" of milk

Milk quality is not only what is inside product. It also relies on the quality of the milk production. This is what we call in INTAQT the "One Quality" that combines intrinsic quality traits — sensory, nutritional, technological and health-related traits — with extrinsic dimensions reflecting consumer and citizens' expectations regarding in particular animal welfare and the environmental and climate footprint of production chains. European dairy production is characterised by a remarkable diversity of farming systems, shaped by contrasting agro-climatic conditions, traditions and market contexts. At one end, low-input grassland farms rely on grazing and hay, with little or no concentrates. At the other end, high-input housed systems feed large amounts of maize silage and concentrates to high-yielding cows, with no pasture access. In between, mixed systems combine grazing with maize silage and concentrates in various proportions. Understanding how this diversity affects milk intrinsic and extrinsic quality is essential to help each production system valorise its strengths.

The "One Quality" of animal products combines the intrinsic quality of the product with extrinsic dimensions including feed-food competition, environmental footprint, and animal welfare. Across 80 European dairy farms classified along an intensification gradient, INTAQT shows that grass-based systems deliver a distinctive bouquet of benefits: nutritionally superior milk, preserved food safety, net protein production for the food system, higher regulating ecosystem services and better welfare proxies — at the cost of lower productivity and a sensory profile that departs from familiar standards.

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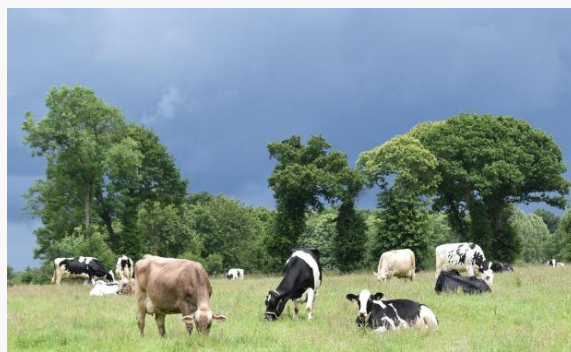
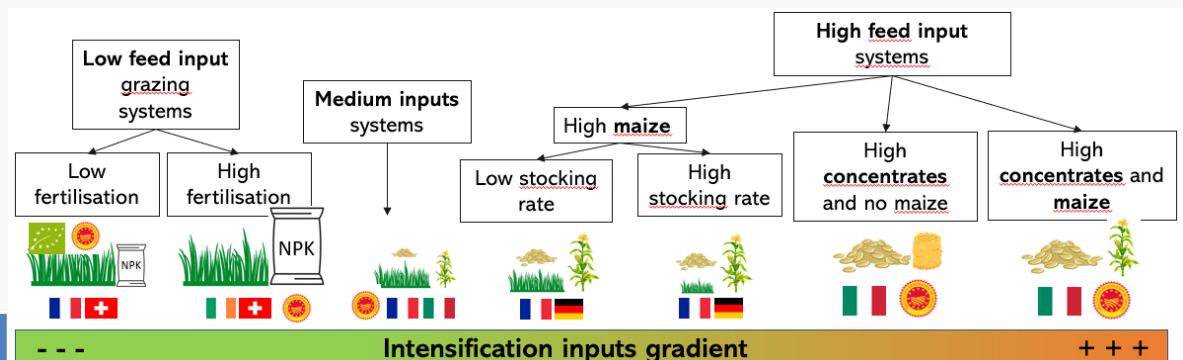


Fig 1: Illustration of the diversity dairy farming systems

A network of 80 farms from 5 countries (France, Germany, Ireland, Italy and Switzerland) was designed in order to cover the diversity of production systems currently found in Europe. Farm structure and farmers' practices were recorded thanks to surveys used to classify farms into 7 main types, ordered by increasing level of inputs (Table 1). In each farm, tank milk samples were collected analysed by a network of 10 academic laboratories. Milk was also collected in specific farms for processing into Parmigiano Reggiano cheese and UHT milk (Figure 2).



Fig 2: Milk sampling and analyses.



Farm types	Intensification inputs gradient						
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Stocking rate, LU/ha	0.6	1.4	1.0	1.2	1.1	2.3	5.9
Pasture, % year	58	50	46	27	5	0	0
Concentrates, % diet	1	0	20	28	29	45	45
Maize silage, % diet	0	0	0	33	47	0	35
Milk yield, t/cow/y	5.1	6.0	6.7	9.4	10.3	9.4	8.6
Milk yield, t/ha/y	2.0	7.2	4.3	7.1	9.4	14.3	33.4

Table 1: Main characteristics of the farms classified along a gradient of inputs

The study investigated a continuum of farming systems, ranging from pasture based production with no concentrate to farms where cows are kept inside all year round and fed high quantities of concentrates and maize. Animal and land productivity expressed in kg protein produced per livestock unit (LU) or ha (including farm land and “imported land” through feed purchase) almost doubled from the grass-based farms to the 4 most intensive farm groups where it reached about 220 kg 250 kg protein per LU and ha respectively.

The analyses included traits related to

- **Intrinsic quality traits** including technological traits (gross composition), sensory attributes (colour, appreciation by naïve consumers), nutritional value (fatty acid, minerals, vitamins, oligo-elements) and safety (myco- and plant-toxins, heavy metals and other environmental pollutants)
- Extrinsic quality traits related to productivity, feed efficiency, feed-food competition, ecosystem services and animal welfare indicators.

Most milk gross composition, including fat and protein, varied among farm types without a clear intensification trend. In contrast, milk from grass-based farms contains about twice as much n-3, vitamin E and B2 as milk from the most intensive farms, which were richer in vitamin B5. Vitamin B12, calcium, iodine and most trace elements varied without a consistent association with grass feeding. None of the analysed contaminants exceeded regulatory thresholds: aflatoxin M1 was higher in some farms using large amounts of maize silage and concentrates, but always below the limit. Sensory differences across UHT milks and cheeses are real but modest for consumers: grass gives yellower, more flavoured products, yet blind tests revealed no preference (cheese) or a slight dislike of pasture milk, mainly because it departs from familiar standards.

There is not a single farming system outperforming all others in term of intrinsic quality. The benefits of grazing systems mainly concern nutritional traits, but grazing does not improve all traits (e.g. vitamin B5) and may have an adverse effect on the sensory properties of ready-to-eat products when consumers are not provided with information about farmers' practices.

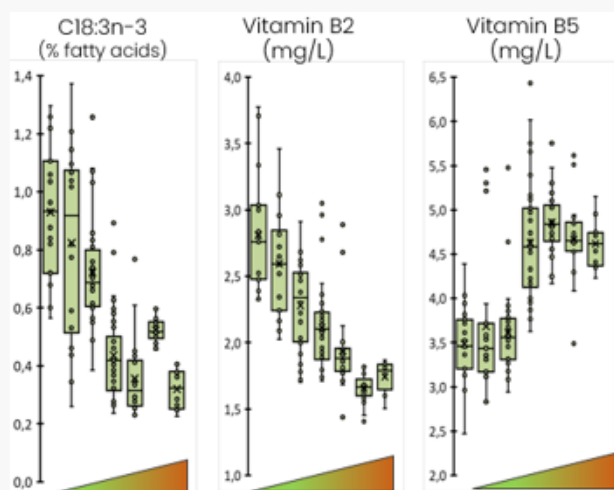


Fig 3. How intensification affects milk nutritional quality

Compared to the most intensive systems, grass-based systems had a lower gross feed efficiency (6 vs 4 kg of feed protein per kg of protein from milk and meat). When only human-edible feed and arable land are considered, however, the picture reverses: intensive dairy farms require 1.9 kg of human-edible protein per kg of protein from milk and meat, whereas grass-based systems require almost none and most of them become net producers of human-edible protein — a threshold reached as long as concentrates remain below 386 g per kg of milk. Intensification also reduced the provision of regulating ecosystem services (carbon sequestration, water regulation, soil quality, habitats), which relies on permanent grasslands. Finally, welfare proxies (mastitis and subclinical acidosis frequencies, pasture access) deteriorated in the most intensive farms, suggesting a lower animal welfare in these systems

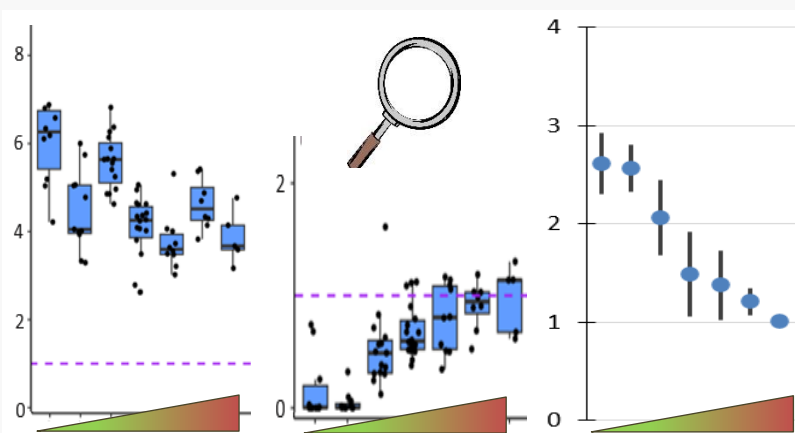


Fig 4. How intensification affects gross (A) and net (B) feed efficiencies* and regulating ecosystem services (C).

*Kg of feed proteins (all feed (A) or human edible feed (B) used to produce 1 kg of proteins animal protein (milk + meat),

European dairy production encompasses a large diversity of farming systems, ranging from low-input grassland farms relying on grazing and hay to high-input housed systems fed maize silage and concentrates, with mixed systems in between. Across this gradient, the proportion of grass in the cows' diet emerged as the key driver of milk quality differences. Grass-based milk contains about twice as much n-3 fatty acids, vitamin E and vitamin B2 as milk from the most intensive farms, which are conversely richer in vitamin B5. Grass-based diets also offer major extrinsic advantages: most grass-based dairy farms are net producers of human-edible protein while intensive systems compete with human food. They additionally provide higher regulating ecosystem services and better welfare proxies. In return, they show lower productivity, and their milk's yellow colour and stronger flavours can be disliked by blind consumers, making consumer information essential.



Fig. 4. A Parmigiano Reggiano cellar

An important finding is that, regarding the “One Quality” of milk, we did not evidenced any farming system outperforming all other ones for all quality traits. Grass-based systems perform best on nutrition, provision of ecosystem services, feed-food balance and animal welfare, while intensive systems excel in productivity and efficiency. Each dairy farming system finally offers its own bouquet of quality traits,

The considerable variability observed between farms operating under similar production conditions highlights that significant improvements can be achieved through better management practices, without necessarily changing the production system itself. Such improvements can enhance product consistency, processing performance and consumer satisfaction while maintaining production efficiency.

Key references: Caumette et al. (2026), Agr. Syst.; Gagliano et al. (2025) and Tura et al. (2024), Foods; El-Khatib et al. (2026), J. Agric. Food Chem.; Mouhanna et al. (2026), J. Dairy Sci.