

Intrinsic quality according to farming systems in dairy

The INTAQT project investigated the relationships between farming systems intensification and tank milk quality in 80 very diverse farms from 5 countries (France, Germany, Ireland, Italy and Switzerland).

Dairy farming systems strongly influence some intrinsic milk quality traits (n-3 fatty acids, vitamins E and B2), while fat and protein contents, most minerals and technological traits vary without a clear trend related to intensification. Sensory properties shift with grass proportion, and food safety is preserved across all systems.

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Milk and dairy products are a staple of European diets and a major source of affordable, high-quality animal protein and micronutrients. Whatever the production system, cow's milk remains naturally rich in high-value protein, calcium and vitamins, making it an important component of healthy and sustainable diets.

Consumers, retailers and policy makers increasingly expect production systems that combine efficiency with high-quality products, while grass-based, organic and PDO systems are gaining importance. Although the effects of dairy farming systems on productivity are well documented, much less is known about their impact on the intrinsic quality of milk and dairy products, including nutritional value, technological and sensorial properties, and food safety. Understanding these relationships is essential to help producers optimize management practices — such as the balance between grass, maize silage and concentrates in cows' diets — while maintaining competitiveness and meeting societal demands.

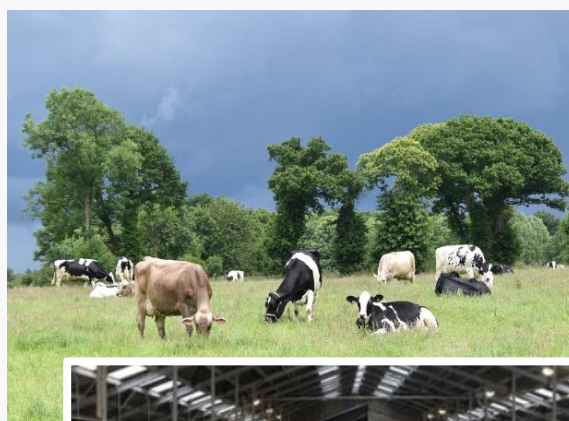


Fig 1: Illustration of the diversity dairy farming systems

Bulk-tank milk samples (394) were collected in 80 farms from 5 countries (France, Germany, Ireland, Italy and Switzerland) covering the diversity of production systems currently used in Europe. These farms were classified into seven main types by increasing level of inputs (pasture use, concentrates, maize silage, stocking rate, fertilisation): (Table 1).

In each farm, the samples were collected 3 times in summer and twice in winter and 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.

	<div><div><div>Low feed input <u>grazing</u> systems</div><div>Low fertilisation</div><div></div></div><div><div>High fertilisation</div><div></div></div></div> <div><div>Medium inputs systems</div><div></div></div> <div><div>High feed input <u>systems</u></div><div><div>High <u>maize</u></div><div><div>Low <u>stocking</u> rate</div><div></div></div><div><div>High stocking rate</div><div></div></div></div><div><div>High <u>concentrates</u> and no maize</div><div></div></div><div><div>High <u>concentrates</u> and <u>maize</u></div><div></div></div></div>						
Farm types	<div><div>---</div><div>Intensification inputs gradient</div><div>+++</div></div>						
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 practices, 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. Milk yield per animal logically increased along the gradient of inputs even if it plateaus for the 4 high input systems (Table 1). Still, milk yield per ha continue increasing due to stocking rate, when we don't consider the "imported land" through purchased feeds.

The analyses included traits related to

- **Technological and sensory** properties: fat, proteins content and composition, somatic cells, microbial ecosystems, colour, appreciation by naïve consumers
- **Nutritional** value: fatty acid, minerals, vitamins B and E, oligo-elements,
- **Safety**: Myco- and plant toxins, heavy metals and other environmental pollutants including, dioxins, PCBs and PFAS.

Most **technological** quality traits, including fat and protein contents varied among farm types without a clear intensification-gradient trend. In contrast, several **nutritional** quality traits showed marked, consistent differences along farms types. Milk from low input farms contains about twice as much n-3, vitamin E and B2 as milk from the most intensive farms that were richer in Vitamin B5. Vitamin B12 varied across systems without a consistent input gradient. Calcium, phosphorus, iodine and most trace elements differed little across systems.

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.

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.

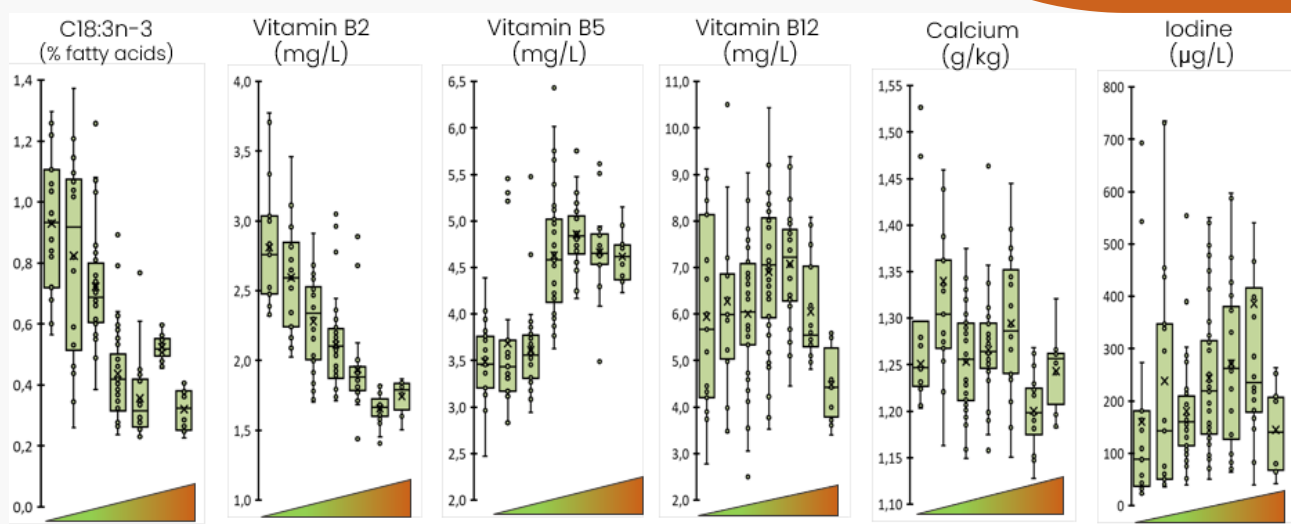


Fig 3. How intensification affects milk nutritional quality



UHT milks. (standardised, homogenized, unskimmed) were made in winter and spring from 15 French farms of three types: from the one maximising pasture to the ones maximizing maize-silage. Winter and spring UHT milks from pasture-based farms were the least appreciated by French and Italian consumers who judged them less white, less fluid, less sweet, with stronger “cowshed”, “malty” and “metallic” flavours. In contrast, the UHT milks from farms maximizing maize silage were the most appreciated, matching the standards consumers are used to.

Parmigiano Reggiano cheeses from farms using hay-only rations were compared with cheeses made from milks from farms where 1/3 of hay was replaced by fresh cut grass. The latter produced yellower cheeses with stronger odours and aromas and a less soluble texture. Italian consumers expressed no average preference for either, as distinct consumer profiles favoured more or less yellow and granular cheeses.



Fig 3. Ready-to-eat products tested by naïve consumers

These findings highlight that farming systems matter for some milk quality traits, but not all. The clearest system effects concern nutritionally relevant minor compounds (n-3 fatty acids, vitamins E and B2), driven by the proportion of grass in the diet. In contrast, milk gross composition (fat, protein) and minerals show no intensification trend — they reflect combinations of genetics, physiology and feeding beyond farm typology. Food safety is preserved across all systems: we found no contaminant above regulatory thresholds even if aflatoxin M1 was slightly higher in milks from farms using large amount of maize. The pasture access did not increase milk contamination.

Sensory differences across ready-to-eat products are real but modest in consumer terms: grass gives yellower, more flavoured milks and cheeses, yet blind tests revealed no preference (cheese) or a slight dislike of pasture spring milk (UHT), mainly because it departs from familiar standards.

An important finding is the a substantial variability that we observed for most milk quality traits, in particular the nutritional ones, suggesting that this variability could be taken into account in nutritionists' assessments. The most significant changes were mainly associated with the proportion of grass in the diet. However, the concentrations of many compounds of nutritional interest did not vary according to the input level and we did not evidenced any farming system outperforming all other ones for all 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.



Fig. 4. A Parmigiano Reggiano cellar

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.