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*in*

**Mena Y. (ed.), Castel J.M. (ed.), Morand-Fehr P. (ed.).**
**Analyse technico-économique des systèmes de production ovine et caprine : méthodologie et valorisation pour le développement et la prospective.**

**Zaragoza : CIHEAM / FAO / Universidad de Sevilla**
**Options Méditerranéennes : Série A. Séminaires Méditerranéens; n. 70**

**2006**
pages 213-226

# A new approach to the measurement of potential quality in grazing systems

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**SUMMARY –** The authors propose a new approach to the evaluation of the potential quality that production systems and, in particular, grazing can achieve. As a result, the initial proposal is to produce a system for defining the types of quality that are to be measured in the products and, subsequently, to specify for each single product, the most representative parameters and the factors conditioning their content. Ultimately, indicators will be proposed for the monitoring of each production system.

**Keywords:** Production system, potential quality, animal products, indicators of quality.

***RESUME –*** *"Nouvelle approche pour la mesure du potentiel de qualité dans les systèmes au pâturage". Les auteurs proposent une nouvelle approche pour évaluer le potentiel de qualité qu'un système productif, en particulier en ovins et caprins, est capable d'exprimer. Pour ce faire, il est d'abord proposé une codification des typologies de qualité qui sont prises en considération dans un produit et ensuite, pour chacune d'entre elles, les paramètres qui l'expriment le mieux et les facteurs qui en conditionnent, à l'intérieur de chaque produit, le contenu. En conclusion il est proposé des indicateurs predictifs qui doivent être pris en considération, dans chaque système de production.*

***Mots-clés :*** *Système de production, potentiel de qualité, systèmes au pâturage, indicateurs de qualité.*

## Introduction

Many investigations on sheep and goats have been carried out over fairly large areas in the past in order to acquire better knowledge about both the sector and its evolution (Castel *et al.,* 2004; Rubino *et al.,* 2003; Dubeuf *et al.,* 2001). In this report, we wish to dwell on just one particular aspect of the agricultural systems: the quality of production.

Due to the recent pressure of public opinion increasingly demanding healthy and good quality food products, research has virtually abandoned studies concerned with quantity in favour of those relating to quality. However, since the concept of quality has no universally accepted definition, neither is there any real harmony apparent in the various opinions expressed on the subject. The most striking case is that regarding milk payments, since, in many parts of the world, milk is paid on the basis of quality, using parameters (fats, protein, bacterial content and somatic cells) which differ to those studied by researchers (aroma, n-3, antioxidants, etc.) and, which, moreover, have little relation to the idea of quality as perceived by consumers. The latter require a product that is, first and foremost, healthy and unpolluted and, secondly, something with taste, aroma and, better still, with a high nutritional value. In the light of this, those wanting to establish themselves in the field of the analysis of animal husbandry and the study of the quality of productions must either follow the old method of research which, as shown above, merely photographs and consolidates the great differences between quality as studied by the world of research and that recognised by the consumers, or they must try to follow paths as yet unknown. As a result, those currently wanting to investigate goat production systems in order to judge the aromatic potential of the milk, would be unclear as to which parameters should effectively be used.

In this report, we do not wish to review what has already been studied on the subject but, more simply, beginning with some of the significant data available, would hope to propose a model for the analysis and monitoring of the systems in use and which will permit forecasting of the qualitative potential that any such a model can achieve. Consequently, in order to arrive at this objective, we have been obliged to define a concept of quality in accordance with a reading that best represents consumer interests. After an initial definition of the different elements of quality in question, we have attempted to select the parameters that can be used to measure them and the factors which influence them. Ultimately, we have tried to propose the indicators which need to be identified.

## Aromatic quality

### Parameters to be measured

This aspect of quality involves, above all, the aromatic characteristics of milk. Whatever the milk or dairy product concerned, even where there are good nutritional aspects, it is unlikely to be eaten if its sensory components are unpleasant. The parameters which can express this quality can influence the organoleptic characteristics of milk and cheese both positively (by increasing its acceptableness) and negatively (some smells and aromas adversely condition the aromatic qualities of milk and cheese and, in particular, those which are unpleasant due to defects in the cheese).

Parameters to be considered refer to the VOC (volatile organic compounds): terpenes (mono-terpenes and sesquiterpenes), ketones, alcohols, esters, etc., which condition the characteristics of the products (milk and cheese) with regard to odour and flavour.

### Determining factors

#### *Feeding systems*

With regard to grazing systems, such as those used in the majority of the Mediterranean countries, the available herbage changes considerably throughout the seasons both in terms of biomass and quality. In these cases, the main objective, is to identify the differences between under cover and open grazing systems and to establish if and where there is a need for supplementary feeding.

The profile of the volatile compounds present in the milk of grazing animals, when compared to those fed undercover, appears quantitatively and qualitatively different.

Fedele *et al.* (2000 and 2005) have demonstrated that, in goats and in experimental conditions (southern Italian pasture), the volatile compounds that characterize the milk of grazing animals, both in spring and summer, are: alpha-pinene, p-cymene, alpha+gamma-terpineol, camphene and sabinene. On the other hand, the milk from indoor goats is characterized by a lower content in total monoterpenes and a lower number of components.

The addition of concentrate sources to the diet does substantially modify the volatile compound profile in the milk; in certain periods it has a diluting effect on its components whilst, in others, it concentrates them.

Fedele *et al.* (2001) and Claps *et al.* (2001) observed, in grazing goats, that the supplementation of the natural diet, native herbaceous pasture in a Basilicata (southern Italy) valley at 360 metres above sea level (with vegetation dominated by grasses in both winter and spring – 75-85% and 55-65% respectively – and by forbs in the summer – 50-55%), with a variation of more or less rapidly degradable concentrates in the same amount per head/day (500 g D.M.), causes a substantial dilution of VOC in the milk profiles when compared with a system of grazing alone.

Within any grazing system, the seasons affect the number of plant species present in the pasture, the mean composition of the diet consumed by the animals and, consequently, the aromatic characteristics of the milk. Fedele *et al.* (2000) have observed that the number of aromatic compounds present in a pasture is very high in spring (58) when compared to those identified in the summer (18). Seasonal evolution also influences the botanical composition of the diet, in terms of higher or lower number of species present in the pasture.

In spring, in the Basilicata valley the goats select a larger number of species with a balanced division between grasses (*Lolium perenne* and *Dactylis glomerata* - 18%), legumes (*Medicago polimorfa* and *lupolina* - 21%) and other botanical families (forbs: *Galium verum*, *Rumex* sp*., Plantago lanceolata*, *Geranium* sp. - 23%). During the summer period, due to the reduction in the number of grass and legumes species, the goats opt for a diet mainly of species belonging to the forbs family (*Centaurea* sp*., Asperula odoratum, Chicorium* sp*., Galium verum, Convolvulus arvensis* and *Crepis* sp.).

The volatile components in the milk differ considerably during the seasons, as does the botanical composition of the diet. Ketones, alcohols and monoterpenes, in order of decreasing importance, characterize the milk produced in spring. In the summer, on the other hand, sesquiterpenes are present alongside the monoterpenes although they are absent in milk in the spring. Therefore, the profile of volatile compounds in milk changes with the seasons and with the species present in the pasture and, as stated by Fedele *et al.* (2000), the same may be true for goats in other, as yet unobserved, situations.

The botanical composition of a pasture is influenced by its altitude, as well as by the seasons and, as the altitude increases, so does the proportion of dicotyledones (*Geranium* sp., *Galium, Asperula,* etc.) in the pasture and in the animals' diet. These plants, especially rich in sesquiterpenes in summer (Carpino *et al.,* 2004; Battelli *et al.,* 2004), change the "nature" of the milk, depending on its origin (Claps *et al.,* 2001; Fedele *et al.,* 2005). Buchin *et al.* (1999) reported that the aroma content of milk depends on the botanical composition of the pasture; milk and cheese from highland areas were characterized by a more distinctive aromatic profile.

The herbage of natural pastures in general, and especially their botanical composition, can be used, therefore, as elements of aromatic diversification in milk and cheeses.

The content of aromatic-type molecules can vary greatly, according to the type of plant and its stage of growth. Common grasses have a smaller number of molecules and a smaller quantity of aromatic substances compared to *Rubiaceae, Gentianaceae* and *Compositae.*

An increase in the diet of Yellow Bedstraw *(Galium verum*), Common Chicory (*Cichorium intybus*) and Sweet Woodruff (*Asperula odorata*) produces a corresponding increase of sesquitepenes in dairy products. Conversely, an increase of Orchard Grass (*Dactylis glomerata*), Perennial Ryegrass (*Lolium perenne*) and Dovefoot Geranium (*Geranium molle*), results in a lower level of sesquiterpenes.

Each of these plants can represent a specific indicator of quality in milk. For example, an increase from 11 to 35% of Sweet Woodruff in the diet caused an increase of unidentified terpenes in the milk from 32 to 47% (Fedele *et al.,* 2005).

Whilst an increase of Orchard Grass in the diet from 64% to 90%, increased the content of $\alpha+\beta$ terpineol from 4 to 27%. These results concerning the relationship of terpenes in milk and the botanical composition of the pasture, confirm the results obtained from other authors (Mariaca *et al.,* 1997; Bugaud *et al.,* 2002 and Carpino *et al.,* 2004) about the fundamental role played by the species of plants by animals selected.

### *Animal factors*

The breed of an animal represents an important factor in evaluating the aromatic quality of its milk since this is always an expression of a determinate management system. The most productive and highly specialized breeds are synonymous with highly specialized intensive systems (dairy cattle). On the other hand, sheep and goat systems have traditionally been synonymous with extensive systems and local breeds play a very important role. The Podolica cow, whose milk is used for the production of the Caciocavallo Podolico cheese and which is reared in the south of Italy in extensive systems, is an example of an inseparable bond with the territory and can be used as an indicator of the quality of the system under which it is raised.

Breed also influences aromatic quality. In effect, with the restriction of the field of research to proteins alone, only partial and often self-defeating results were detected, as demonstrated by the polymorphism of the alpha-s1 casein in goats: the favourable increase of the frequency of this casein involved a diminution of the "goaty" taste, which was considered negative by consumers (Pierre *et al.,* 1998).

Pizzillo *et al.* (2005) observed differences in the "goaty" flavour and in the rehological properties in ricotta cheese made from the milk of different goat breeds. These differences may be related to the different ratio of lipolysis and/or different frequencies of the alpha-s1 casein locus alleles.

Other research on goats (Grosclaude *et al*., 1994; Remeuf, 1993) has highlighted the significant effect of the genotype on the casein, fat and coagulative content in milk. These same authors have also illustrated how there is a greater tendency to the coagulation of the rapid phenotype (high casein content) over that of slow phenotype (low casein content) within the same breed. The milk from indigenous goats in southern Italy (Marletta *et al*., 2004; Ramunno *et al.,* 2001) reveals a low calcium sensitive casein content (alpha-s1, alpha-s2 and beta).

Such results would appear to suggest that, apart from its chemical, nutritional and technical qualities, the milk of such breeds might be advantegeously used as a "special" milk product which is particularly easily digestible due to its low casein content.

In cattle, genetic factors can modify the organoleptic and, in particular, the rehological characteristic of cheeses, especially with regard to the relationship of fat/protein.

Research in France (Verdier-Metz *et al.,* 1998; Martin *et al.,* 2000) comparing Sainte-Nectaire cheeses made, in controlled conditions, from Holstein and Montbéliarde milk, has highlighted the differences resulting from the change in breed. In a first experiment, the cheese produced with full-fat milk from Holstein cows was less firm and was softer than that produced by the Montbéliarde cows, due to the greater percentage of fats in the dry substance and caused by the relationship of fats to protein in the Holstein cows' milk. On the other hand, where there was a standard relationship of fats to protein, no differences were observed before cheese making.

### Indicators used to estimate quality

Table 1 shows the data collected in a production system and used as indicators of aromatic quality. They are, almost exclusively, influenced by the feeding systems.

Table 1. Main indicators used to estimate aromatic quality

| Parameters | Indicators of quality |
|---|---|
| Terpenes and other VOC | Feeding systems<br>- management systems (grazing or under-cover)<br>- stocking rate (heads/hectare)<br>- botanical composition of pasture (% of grasses, legumes and forbs)<br>- principal aromatic plants ingested and relative vegetative growth<br>- hay type used indoor (1 or more species of plants)<br>- concentrate supplementation (type and quantity)<br>Altitude (m)<br>Exposure (north, west, east, south)<br>Season<br>- winter, spring, summer, autumn<br>Animal factors<br>- breed (sensory analyses), level of production (high - medium - low) |

## Nutritional quality

Generally speaking, cheeses are bought because they are liked and, therefore, for hedonistic reasons. Nonetheless, they are discouraged by dieticians for their cholesterol content and, therefore, for nutritional reasons.

Consequently, the nutritional approach to cheese is almost always negative. However, there are numerous molecules in cheese that have a recognised nutritional function and there are a number of factors conditioning their content.

## Parameters to be measured

Amongst the most significant molecules that express nutritional quality are: fatty acids (FA) of the n-3 series, CLA (conjugated linoleic acid), antioxidants, oligo-elements and vitamins. The more common n-3 fatty acids, belonging to the family of the polyunsaturated fatty acids (PUFA), are the alpha-linoleic acid, the eicosapentaenoic acid (EPA) and the docosahexaenoic acid (DHA).

The n-3 fatty acids: (i) Reduce total cholesterol and low-density lipoprotein cholesterol (LDL) levels, but increase high-density lipoprotein (HDL) cholesterol; (ii) Counteract hypertension; (iii) Play a role in the regulation of hormonal secretion; and (iv) Are beneficial in the care of skin pathologies and are also useful in the therapy of arthritis and other inflammatory problems.

The acronym CLA (conjugated linoleic acid) is used to express the mixture of isomers of the linoleic fatty acid with double conjugated bonds, located, above all, on the atoms of carbon 9 and 11. Biological activity is mainly attributed to rumenic acid (C18:2 cis9, trans 11), which represents about 90% of the total isomers present in the fat of ruminants (Di Trana *et al.,* 2004). The CLA in milk has two origins: from the rumen bio-hydrogenation of unsaturated fatty acids, present in substantial quantities in fresh forage; and from the synthesis in animal tissue, mainly the mammary gland and adipose tissue, starting with the vaccenic acids through the action of the delta9-desaturase enzyme.

The studies carried out until now on animal models have emphasized the efficacy of CLA in the prevention of cancers, infections, and atherosclerosis. Its anti-carcinogenic activity can be about 100 times greater than that of omega-3 fatty acids.

Recently, another topic of interest has been the antioxidant content in milk and cheeses. The parameters that are taken into consideration are the beta-carotene and vitamin E content and the level of protective antioxidants. A molecule is recognized as an antioxidant when it is able to slow down, or hinder, oxidizing processes against certain substances. A synthetic index of this capability is represented by the degree of antioxidant protection (DAP) (Pizzoferrato and Manzi*,* 1999). The DAP is the ratio of the antioxidant element (e.g. alpha-tocopherol) and the element to be protected against oxidation (the cholesterol).

## Determining factors

### *Feeding systems*

Fresh grass is the main source of alpha-linoleic acid and this explains why milk produced from grass-based diets contains more C18:3 n-3 than those which are maize-based or concentrate-rich. It is mainly in the spring and in the autumn that FA content and C18:3 n-3 concentrations are highest in grass, explaining the sharp increase of linoleic acid in milk caused by turning the animals out to pasture. This increase can be as high as 2.5% of total FAs.

Many studies (Collomb *et al.,* 2002; Di Trana *et al.,* 2003; Claps *et al.,* 2005) have shown that where grazing is used, DHA in cow and goat milk reaches its highest concentration in winter whilst the lowest values are recorded in the summer and spring.

The study by Di Trana *et al.* (2003; 2004) compared grazing goats with indoor fed animals in different seasons and demonstrated that those out to pasture eating exclusively grasses, produced milk with a CLA content almost double that of those fed under cover with hay and 600g/per head/per day of concentrates.

The grazing season, with its different botanic composition and the differing phenological stages of the plants, modifies the CLA content of the milk. In the winter, when the plants are young and in the full of their vegetative stagnation period and when the pasture is made up mainly of grasses (*Lolium perenne, Dactylis glomerata, Bromus ordeaceus*, etc.), the milk has a higher CLA content. These variations also correspond to the linoleic acid content in the foods which, with an average of 50% in grass, become about 6% of the sum of the fatty acids methylic esters (FAME) in the rations of the goats fed under cover and to an average level of 40% on the total FAME of pasture grass grazed in winter (Di Trana *et al.,* 2004; Fedele, 2005). Grass loses its capacity to enrich milk with CLA as the stagnation period continues, because it becomes less rich in linoleic acid.

Various studies attribute to young herbage, because it is richer in precursors, a more marked influence on CLA when compared to that in a more advanced state of senescence (Collomb *et al.,* 2001; Chouinard *et al.,* 1998). The highest levels of CLA were detected (in goat milk) during the winter, when early growth stage herbage plays a fundamental role in the CLA increase in comparison to diets including general-growth herbage (Di Trana *et al.,* 2003). The positive effect of grazing systems on CLA was confirmed by others (Kelly *et al.,* 1998; De Brabander *et al.,* 2003).

It is not only the growth stage of the vegetation, but also specific plants present in the pasture and palatable to the animals which can influence CLA content in milk fat. Collomb *et al.* (2002) have observed a positive correspondence between the CLA content and the presence in the pasture of both *Apiaceae* and *Asteraceae* species. Di Trana *et al.* (2004), on the other hand, have highlighted a positive relationship between the presence of a specific grass, *Lolium perenne*, in the pasture and the CLA content in goat milk. Dewhurst *et al.* (2003) when evaluating the effect of grass and legume silage on milk quality, reported that red clover increased by 240% the alpha-linoleic content in milk fat when compared with grass silage. These differences reflect the higher rumen outflow rates of legume silage in comparison with grass silage.

Feeding systems also significantly influence vitamin A and E content in both milk and cheese.

Vitamin A in milk derives from blood previously filtered at the mammary gland level. The yellow colouring of the cows' milk fat corresponds above all to the beta-carotene content (Prache *et al.,* 2002). In goat milk, vitamin A is present in its own right and not in Beta-Carotene form and, for this reason, their milk is white.

The basis of the forage determines the considerable variations in the vitamin A content in milk. In cows' milk, the highest concentrations have been found in milk produced by animals fed in pastures when the grass is young or with *Loiessa* silage, whilst the lowest are to be found in animals fed with hay and concentrates (Martin *et al.,* 2002).

It has been highlighted (Fedele *et al.,* 2004) that, in goat milk, where the concentration of rations is equal, that produced by grazing goats contains 20% more trans-retinol. This difference increases by 31% when compared with the milk from grazing goats without any integration.

The feed given to the animals, green or preserved, forage or concentrate, represents the main cause of variations in the vitamin E content in milk.

Research carried out on cows (Thompson *et al.,* 1964) and goats (Pizzoferrato *et al.,* 2001) has shown that pasture grass, more than hay or concentrates, enriches milk and cheese with alpha-tocopherol.

These substances, of great importance both for their specific action and for their antioxidant properties, increase more in milk derived from the various grazing systems and more greatly in those from mountain pastures (Pizzoferrato *et al.,* 2000). The degree of antioxidant protection is, in all cases, higher in the milk of grazing goats (Pizzoferrato *et al.,* 2000). The use of any kind of concentrate supplementation, as feed integration to the pasture, causes a considerable decrease in the DAP.

The integration of the diet, necessary in grazing systems in order to satisfy the animals' requirements for the production of an acceptable amount of milk, can modify, according to the nature of the concentrates used, the nutritional characteristics of the milk produced.

In goats, when comparing 26 diets combining different forages (Chillard and Ferlay, 2004), concentrate percentages and lipid sources, it appears that the highest milk oleic percentages (more than 24% of total FA) are to be obtained either with unprotected high-oleic sunflower oil (and more with alfalfa hay or rye-grass than with maize silage) or with oilseeds ranked as lupine>soybean>linseed>sunflower.

The case of lupine seeds is particularly interesting because it is rich in 18:1 and C18:2 and is the only seed which does not decrease the desaturation ratio and which did not increase (or even decrease) goat milk PUFAs and vaccenic acid.

With most non lipid-added diets, the proportion of linoleic acid (C18:2) in milk fatty acids is classically between 2 and 3%. When rations are supplemented with linoleic acid-rich seeds or oils such as soybeans or sunflower, these proportions rarely exceed control values by more than 1.5% (these results were obtained with cows).

A comparison of sunflower oil and seeds in goats, revealed that seed lipids C18:2 was, paradoxically, more strongly hydrogenated to stearic acid than oil C18:2 and found intact or in the form of trans FA and CLA in milk. Therefore, it may be supposed that the slow release of seed lipids enhances their total hydrogenation, at least in goats (Chilliard and Ferlay, 2004).

The addition of linseed oil (C18:3 rich) to cow or goat diet decreased milk linoleic acid percentages, probably because it increased the linolenic acid percentages.

With regard to linolenic acid, apart from forage, only linseed can provide a very high level representing more than 50% of FAs. The method of supplying the integration has a determining role. In effect, in goats, the response to extruded linseeds seems to be different since linolenic acid increased more than after linseed oil supplementation (Giger-Reverdin *et al.,* 2001).

Many studies have evaluated the effects of dietary factors on the increase in CLA levels in milk. Whitlock *et al.* (2003) found that levels of trans-vaccenic acid and CLA in milk increased when cows were fed with high oil corn rather than with pasture. Moreover, the production of trans-vaccenic acid and conjugated linoleic acid was attenuated by a high forage diet. The above results were confirmed by the studies of Chilliard *et al.* (2003) who verified the increase in the CLA content where either vegetable oil supplementation or fresh grass feeding was used.

Nevertheless, supplementation with oils did not always improve the nutritional features of the milk. In fact, Chilliard *et al.* (2003) observed an increase of C18:1 trans 11 (vaccenic acid) and CLA contents in milk when the cows' feed was supplemented with linseed oil rather than grass hay or maize silage. The same results were obtained by Ferlay *et al.* (2003) when sunflower oils were used in the diet. These findings demonstrate that manipulation of the diet with feed that is rich in precursors of CLA does not always result in entirely positive effects since an increase in CLA is consistently linked to an increase in trans fatty acids (TFAs).

### *Animal factors*

The production level of the animals, despite the limited research on the subject (Jensen *et al.*, 1999), appears to influence the vitamin and antioxidant content in milk fat. High production levels have a fundamentally diluting effect.

A recent study carried out in Italy (Pizzillo *et al.,* 2005) on the ricotta cheese from different Mediterranean goat breeds (Girgentana, Syrian, Maltese and Local) highlighted the fact that the fatty acid profile of the cheese was significantly affected by the breed type. A higher content of polyunsaturated fatty acids was detected in the ricotta cheese from whey of the Girgentana breed compared to that of the others. This result was due to the higher levels of arachidonic and linoleic acids to be found in this dairy product. These essential fatty acids and their derivatives play an important nutritional role and are of dietetic significance in such products.

These results demonstrate that feeding systems in general and, particularly pasture with an intake of green herbage, considerably influence the nutritional quality of the milk and its by-products.

Research on a number of different indigenous (Gentile di Puglia and Altamurana) and milk (Sarda and Comisana) sheep breeds has shown that there are both chemical and sensorial differences, above all in cheeses aged for eight months. The content of free short chain fatty acids was seen to be greater in cheese made from the milk of the indigenous breeds (Gentile di Puglia and Altamurana) than that of the specialised milk breeds (Sarda and Comisana).

The milk of the indigenous breeds produced cheeses that were sensorially distinguishable from the others by their more intense yellow colour, stronger taste, more distinctive smell and flavour of sheep's cheese and by the curd's greater degree of friability and granularity (Claps *et al.*, 1999; Taibi *et al.*, 2000).

### Indicators used to estimate quality

Table 2 shows the data required for monitoring the nutritional potential of any single system. However, this article will be limited, to reporting only the most significant elements, without going into any greater detail. For each indicator, as for subsequent indicators, it is important to record its effective presence in order to have a general idea of qualitative potential.

Table 2. Main indicators for estimating nutritional quality

| Parameters | Indicators of quality |
|---|---|
| Fatty acids, CLA, antioxidant, vitamins | Feeding system<br>- % rate of grazing in the diet<br>- stocking rate (heads/hectare)<br>- botanical composition of the pasture (% of grasses, legumes and forbs)<br>- main ingested species and growth stage of vegetation<br>- number of plants in the hay or silage<br>- concentrate supplementation (type and quantity)<br>Season<br>- winter, spring, summer and autumn<br>Animal factors<br>- the breed (chemical and sensory analyses) |

Nonetheless, specific studies are necessary to permit a grouping together of the results in types of quality in order to establish data which can be used as parameters rather than being merely descriptive.

## Safety

### Parameters to be measured

In extensive systems, limited industrialization and urbanization, together with the virtual absence of fertilizers and fungicides, ensure ideal conditions for "clean" raw material which is free of pollutants. The possibility for the animals to consume the local forage directly, by grazing on the pasture, or indirectly through the hays, allows all those aromatic and nutritional components typical of this special environment to pass directly to the milk and cheese (Ciccioli *et al.,* 2004; Fedele, 2005).

Due to the strong relationship existing between the characteristics of any given environment and the quality of its milk, a number of harmful substances (aromatic hydrocarbons and/or heavy metals) can be found in the milk produced in large urban centres or highly industrialized areas (anthropogenic) or where highly specialized agricultural methods (fertilizers and fungicides) are used.

The parameters, in terms of pollutants and the atmosphere, to be considered with regard to an evaluation of environmental quality are, therefore, heavy metals, polycyclic aromatic hydrocarbons (in particular the arenes derived from ethylbenzenes and trimethylbenzenes) and dioxins (derived from the burning of solid urban waste and industrial processes using chlorine and its derivates).

## Conditioning elements

### *Distance from the source of pollution*

The diffusion of pollutants into the environment depends on the size of the particles, the degree of volatility of the components and meteorological conditions. Particles larger than 50 microns cannot spread further than 400 metres from the point of their emission into the atmosphere, whilst those between 20 and 50 microns can travel as far as one kilometre. Lighter polycyclic aromatic hydrocarbons, weighing less than 4 atoms of carbon, can travel longer distances than those which are heavier (more than 4 atoms of carbon) and will be deposited more quickly after emission (Fedele, 2005).

Recent results (Tuchácková *et al.,* 2001) have shown that the level of soil pollution by polycyclic aromatic hydrocarbons depends on the distance from the source of pollution. In moving from 0.5 m from the road surface to 500 m, soil pollution rapidly decreases. The same can be said for heavy metals (Fedele, 2005; Parkpian *et al.,* 2003) such as lead and cadmium. The latter, at only a kilometre away, decreases to extremely low concentrations (0.02 mg/kg).

With regard to polycyclic aromatic hydrocarbons, motor traffic is considered as one of the main sources of pollution. In a study carried out in Italy (Ciccioli *et al.,* 2004) it emerged that the "arenes" content of C2 and C3-Benzene in milk produced in the proximity to a motorway or a highly urbanized area, is much higher than that found in the milk of mountain farms at a considerable distance from roads and in areas of low-level industrialization. The presence of C2-Benzene passed from 3.77 to 0.27 ppbw (parts per billion weight), whilst those of C3-Benzene went from 24.8 to 0.65 ppbw.

The same can be said with regard to dioxin. The highest concentration was found in milk produced in areas near to the sources of emission (incinerators, chemical plants etc.). In the Campania region in the south of Italy, out of 72 samples of milk analysed from various parts of the area (personal communication by Fedele, 2005), 22 showed dioxin concentrations of between 3.07 and 11.31 mg/g of fat (well above the permitted limit of 3.00 mg/g of fat).

### *Vegetation characteristics*

On a par with environmental pollution, the contamination of plants can vary with regard to leaf surface area and their capacities for retention. Of the vegetable categories, all things being equal, grasses show a higher concentration of particles on their surface than that of other herbages or of trees and shrubs (Fedele, 2005).

The close correspondence between the "arenes" profile of milk with that of motor traffic emissions is highly indicative of the dramatic impact that dry and wet depositing of these sources might have on the quality of milk and its dairy products.

## Indicators used to estimate safety

Table 3 shows the main indicators used to judge the quality of safety in the environment.

Table 3. Main indicators for estimating safety levels

| Parameters | Indicators of quality |
|---|---|
| Benzene, heavy metals, etc. | - feeding systems (grazing or indoor)<br>- feed supplementation (origin of hay and concentrates)<br>- additives<br>- distance from urban centres and industrial plants<br>- distance from high traffic density roads |

## Functional quality

This classification includes all the compounds potentially present in so-called "functional" foods. These have been defined by the Institute of Medicines of the US National Academy of Science as foods that include elements potentially influential on human health.

### Parameters to be measured

In ethnobotanic literature, the plants used in veterinary medicine are distinguished according to their effects: abortive (e.g. *Veratrum album; Hedera helix*), analgesic (*Allium sativum, Convolvulus arvensis*, etc), antidiarrhea (*Triticum durum, Rumex* sp*., Sonchus asper,* etc.), antiecchymosis (*Verbena officinalis, Paritaria officinalis,* etc.), anti-inflammatory (*Achillea millefolium*), parasiticide (*Anthemis cotula*, *Fraxinus ornius, Urtica urens*) and so on, up to the plants with galactopoietic effect (*Borago officinalis, Camomilla recutita*, etc.) (Pieroni *et al.,* 2004).

In fact, both forage and individual plants decisively influence the quality of milk and some herbages would also seem to condition the well-being of animals (Otuki *et al.,* 2005). Animals consume many plants when grazing possibly not only for their nutritional requirements, but also to alleviate states of suffering. This can explain why some plants, indicated by ethnobotany for their anthelmintic properties, are selected by animals in particular circumstances and it may well be that an animal's "pharmacological" requirement for particular plants might indicate equally positive effects for human health (Aliaga and Lissi*,* 2004).

Therefore, the parameters that differentiate medicinal plants from others are linked, above all, to the flavonoid content and their effect on the health of animals may have parallel repercussions on human health when passed from the grass to milk.

### Determining factors

*Grazing behaviour*

The selection by animals out to pasture of plants which may only be present in limited amounts, plays an important role in transferring these secondary metabolites from plants to milk (De Feo *et al.,* 2006; Fedele *et al.,* 2002).

### Some secondary metabolites in milk

The experiences of Fedele *et al.* (2003) and Fedele (2005) have shown a different flavonoid profile in the milk of goats fed borage (*Borago officinalis*) and hawthorn (*Crataegus oxyacantha*).

Milk produced from a borage based diet is unique in containing beta-sitosterol and 5,7,4-triflavonol although it lacks rutin which can be found in the milk of animals feeding on hawthorn.

Rutin is acknowledged to play a role in the prevention of tumours and has an antioxidant activity (Aliaga and Lissi*,* 2004) whilst beta-sitosterol has the ability to inhibit the growth of cancerous cells (Awad *et al.,* 2005).

### Indicators used to estimate functional quality

The main indicators used to estimate functional quality are reported in Table 4.

Table 4. Main indicators to estimate quality

| Parameters | Indicators of quality |
|---|---|
| Flavonoids, etc. | Botanical composition of pasture<br>- Plants used in veterinary medicine |

## Conclusions

In this report we have seen that, despite adopting a new approach and the fact that no-one has, as yet, carried out investigations on the qualitative potential of grazing systems, the results are such as to guarantee their reliability or, at least, that of a significant proportion of the parameters in question. We refer here, in particular, to the hedonistic and nutritional qualities of which the parameters and molecules concerned are sufficiently well known, together with those factors influencing their presence. As a result, it is possible to establish a good approximate method for monitoring typologies and a sufficient number of parameters to forecast an appropriate final evaluation. However, research is limited on functionality and safety and the available data is frequently unusable as it has been collected for different purposes. This does not mean that the subjects are any less interesting since, above all with regard to safety, health assurances are increasingly taking on a (possibly over exaggerated) importance and it can be safely assumed, therefore, that any gaps will be swiftly breached.

It has been suggested that this new approach would permit an evaluation of the potential quality of production systems. It should be added that the most important result could be the use to which this will be put. Until now, the classification of geographic areas (strong, weak, marginal, late developing) has exclusively been made using quantitative parameters. This classification method has been used not only to make judgements about the areas concerned but also to take decisions about development policies. Therefore, a change in reading might signify an analogous change in such policies, steering legislation towards a different approach to the areas guaranteeing quality and safety in their production.

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