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Basic and incentive payments for goat and sheep milk in relation to quality☆

A. Pirisi[a,*], A. Lauret[b], J.P. Dubeuf[c]

[a] *Istituto Zootecnico e Caseario per la Sardegna, Regione Bonassai, I-07040 Olmedo, Italy*
[b] *Institut Technique des Produits Laitiers Caprins, 17700 Surgères, France*
[c] *INRA/SAD, 20291 San Giuliano, France*

Abstract

Dairy sheep and dairy goat breeding in Europe is most common around the Mediterranean basin, particularly in France, Greece, Italy and Spain. Over recent years the tendency has been a slight reduction in the number of animals bred, while at the same time there has been a general increase in the volume of milk produced. The milk of sheep and goats is mainly reserved for cheese making and therefore a quality evaluation of the milk is of fundamental importance. If, on the one hand, the achievement of a certain level of quality is of interest for the cheese making industry, which has to deal with the ever-increasing demands of the consumer, it is also of interest to the milk producers, who can increase their earnings by pursuing high quality. The quality of the milk for cheese making depends essentially on its physical and chemical composition and on hygienic and sanitary factors (bacterial count, somatic cells count, etc.). The price of sheep and goat milk is generally higher than that of cow milk, even though in certain areas of production it is not specifically exploited, being blended with cow milk for the production of mixed cheeses. Differentiated pricing in relation to quality is becoming ever more widespread also for sheep and goat milk. This is mainly based on the construction of a grid on which various parameters are taken into consideration in order to establish bonuses and penalties, which are then applied to the base price of the milk. This paper summarises some previous works on this subject and integrates them with the new scenarios, while at the same time discussing how to improve the quality and subsequently the valorisation of these milks.
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Keywords: Sheep industry; Goat industry; Milk quality; Quality control; Payment system

1. Introduction

The main use for sheep and goat (S&G) milk in the world is for cheese making that is usually conducted at farm level or in small local dairies, in particular in Mediterranean and South-East European countries, although some big cheese factories can also be found, mainly in Western Europe. Over the past few years, the S&G milk dairy industry, along with the other agro-food sectors, has considerably developed its production capacity by increasing the industrialization and automation of the processes. In the same time there has been an increase and a liberalisation of international trade. These changes were possible thanks to the definition of hygienic and sanitary standards at international level: Codex Alimentarius and European Union Directives, principally. A development policy for the S&G dairy sector combined with financial incentives have allowed this sector to advance and implement a payment system in relation to the quality of the milk. Quality control mechanisms are now largely instituted by interprofessional laboratories which systematically collect and analyse

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* Corresponding author. Tel.: +39 079 387277; fax: +39 079 389450.
E-mail address: apirisi@tiscali.it (A. Pirisi).

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milk samples. Mechanisms of this nature, particularly well-organised in certain countries such as France, Italy (Sardinia), Taiwan and Spain, are developing fast in The Netherlands, Norway, Portugal and North American countries, but are almost non-existent in Greece and the east of the world.

This paper summarises some previous works on this subject (Pirisi et al., 2000; Dubeuf et al., 2004a,b; Kalantzopoulos et al., 2004; Raynal-Ljutovac et al., 2005) and integrates them with the new scenarios, while at the same time discussing how to improve the quality and thus the valorisation of these milks. After a presentation of the S&G dairy sector around the world, existing payment systems are described together with the impact they have on the evolution of production systems and the quality of products.

2. Sheep and goat milk production in the world

Small ruminants are present all over the world. They are considered to be well-adapted to the grazing (sheep and goat) or browsing (goat) of poor marginal lands, they are often seen as very attractive for small-scale farming in developing countries and less-favoured areas. The FAO statistics (Table 1) show that S&G milk represents 4.25% of the total world milk production with the largest quantities in Asia (3.5 millions tonnes of ewe milk in Turkey, Iran, China, Syria, Sudan and Algeria and 7.5 millions tonnes of goat milk in India, Bangladesh, Sudan, Pakistan, Iran, Turkey, Ukraine, Russian Federation and China). But these data, particularly for the under-developed countries, do not usually include the milk production for kids and lambs after weaning as well as the milk used for family or village consumption. This means that out of the total milk production officially recorded, an unknown quantity is processed directly by farmers or after collection by dairies, and sold on an organized market.

Dairy sheep and dairy goat breeding in Europe is most common around the Mediterranean basin and in the EU, Greece, Spain, France and Italy are the largest producers of S&G milk (Dubeuf and Le Jaouen, 2005). In these countries the production of S&G milk is concentrated in well-defined areas. In Italy 48% of the total production of sheep milk is produced in Sardinia with the Sarda breed. In Spain the most important areas are Castilla and León (70% of the total) with the Assaf and Churra breeds and Castilla-La Mancha (25%) with the Manchega. In France the Roquefort region (82%) with the Lacaune breed is the most important. Greece is one of the most important sheep and goat milk producer in the world. Its S&G sector is kept very traditional with small flocks consisting of local breeds (e.g. Chios, Argos), but settlements of more intensive farms with imported breeds (e.g. Lacaune, Awassi) are observed under the impulse of industrial investors. Nevertheless, payment systems are still little developed (Tsiboukas and Vallerand, 2004). The sheep dairy sector is not well-developed in other countries except for Great Britain, North America, South America and Middle-East, where it is present on a small scale mainly. In particular in USA and Canada production of sheep milk from about 12,000 head started 25 years ago and is growing rapidly annually (Berger et al., 2004; Thomas and Haenlein, 2004). This milk is used exclusively for cheese making and yoghurt production, principally at the artisanal level. Regulations for commercial sheep milk cheese marketing are patterned after the American cow milk regulations (Haenlein, 2000; Haenlein and Wendorff, 2006).

As regards goat milk (Dubeuf and Le Jaouen, 2005), the largest producing areas in France are: Poitou-Charentes, Pays de Loire and Rhône-Alpes and the main breeds are the Alpine and Saanen. In Spain: Andalucía, Castilla-La Mancha, the Canary Isles and Murcia are the most important regions and the main breeds are

Table 1
World goat and sheep milk production in 2005

Goat milk production (tonnes)		Sheep milk production (tonnes)	
India	2,700,000	China	1,120,000
Bangladesh	1,416,000	Italy	820,000
Sudan	1,295,000	Turkey	750,000
Pakistan	660,000	Greece	700,000
France	587,000	Syrian Arab Republic	604,200
Greece	495,000	Sudan	464,940
Spain	465,000	Spain	400,000
Islamic Republic of Iran	365,000	Islamic Republic of Iran	380,000
Ukraine	290,000	Romania	344,000
Russian Federation	259,000	France	264,000
China	256,000	Algeria	200,000
Turkey	240,000	Mali	126,000
Mali	238,590	Bulgaria	115,644
Indonesia	220,000	Indonesia	102,000
Algeria	160,000	Portugal	98,000
Mexico	154,478	Mauritania	96,250
Brazil	135,000	Egypt	93,000
Italy	115,000	Saudi Arabia	82,500
Mauritania	109,800	Albania	76,000
Bulgaria	109,320	Jordan	65,752
Total in the world	11,879,780	Total in the world	7,815,231

FAOSTAT data (2005).

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Table 2
EU limits applicable to the production of raw sheep and goat milk, from Directive 92/46 modified by Directive 94/71

Milk	For the production of products based on heat treated milk		For the production of products based on non-heat treated milk	
Date the requirement came into force	1/1/95	1/12/99	1/1/95	1/12/99
Bacterial count at 30 °C (n/ml)	<3,000,000	<1,500,000	<1,000,000	<500,000

[a]Geometric average observed over a 2-month period, with at least two samples a month.

Murciano-Granadina, Malagueña and Majorera. In Italy: goat milk production is particularly developed in Calabria, Sardinia and Campania with the Locale and Sarda population breeds and the Garganica and Maltese breeds. In Europe the dairy goat sector is also developed in The Netherlands and Norway. Nevertheless, in most of these countries, as in Italy, Portugal and Greece (where the goat milk industry is not well-differentiated from the sheep milk industry) an important part of the production is processed at farm level or in small-scale units. In France the dairy goat sector is very strong thanks to a good ecological image of goat products often associated with holidays on the farm. In the USA, a certain interest for dairy goats started during 1960–1970, and in the 1980s this sector began to be very active with annual production of about 50 million l of milk. The dairy breeds are principally Nubian, Alpine, Saanen and Toggenburg, and quality control has been adopted from cow regulations, while official goat milk standards are still in progress (Haenlein, 2000). A similar situation can be observed in Canada. In other developed countries, the goat sector is small although it may be well-organised like in New Zealand, where a large part of the 14 millions l produced is processed into UHT milk or powder, and is exported to several countries (Dubeuf et al., 2004a,b) and Taiwan with about one-half a million Alpine and Saanen goats imported from USA has a well-organized goat fluid milk industry (Haenlein, personal communication). Israel has also an organised, intensive S&G dairy sector.

Goat milk and its products are now fashionable in some parts of the world, where medical needs and connoisseur interests drive these markets. The success of new initiatives and projects in developing countries (i.e. in Algeria, Morocco, Tunisia, Vietnam, South America, etc.) is varied and subject to several constraints (Dubeuf et al., 2004a,b). Milk collection in these countries is still poorly developed nor well-organised.

3. A milk mainly used for cheese making

The main use of S&G milk is cheese making, although a small amount of goat milk is consumed directly as UHT milk or transformed into yoghurt. The exploitation of S&G milk as such is more important in France and Italy, while in Spain and Greece, a large quantity of mixed cheeses is produced. In this case S&G milk is blended with cow milk and is not specifically exploited. The transformation of sheep milk into cheese is carried out mainly at industrial levels, although in Greece a significant amount of this milk is processed in small dairies by the breeders themselves (about 35%). In the case of goat milk, on the other hand, as much as 80% of the total milk is processed in industrial dairies in Sardinia (Dubeuf and Le Jaouen, 2005), and about 75% in France (estimated from sources Centre National Interprofessionnel de l'Economie Laitière, 2005; Institut de l'Elevage, 2005).

Out of a total of around 550,000 tonnes of S&G milk cheese produced in Greece, Spain, France and Italy, 25% is protected designation of origin (PDO) cheese, much of which is represented by Pecorino Romano, Roquefort and Pecorino Sardo, while the other denominations together account for less than 10%.

4. European regulations and parameters

The criteria of hygienic and bacteriological quality in S&G milk are outlined in the 92/46 and 94/71 EU Directives, which regulate the various aspects of the production and transformation of the milk of various animal species. In the case of cow milk the norms established are very precise, while in the case of S&G milk the limits of some parameters, such as somatic cell count, have not yet been established. Table 2 reports the EU limits for the production of raw S&G milk. These are distinguished by taking into consideration the milk treatment (heat treated or non-heat treated) before cheese making.

Outside of Europe, the limits established for cow milk are more or less applied to S&G milk, as is the case in USA, Canada and Taiwan (Haenlein, 1993).

5. Hygienic quality

5.1. Bacterial count

The bacterial count refers to the number of aerobic microorganisms which develop at a temperature of 30 °C, and is expressed as a number of colony-forming

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units (CFU)/ml. The EU Directives establish the maximum limits admissible (Table 2) for S&G milk with the aim of upholding or improving the quality of raw milk. Microbiological quality control of milk is a very delicate task, given the great variety of conditions to be found in the S&G sector. Lack of milking machines and refrigeration tanks at the farm and transport of milk in unsuitable vehicles have a notable influence on the bacterial counts which can, in particular conditions, reach high levels. These considerations underline the difficulty of obtaining milk with a low bacterial count, since in certain areas this would mean altering the structural characteristics of the farms. It must be pointed out that modernisation of the farms also requires adequate technical training of the shepherd.

5.2. Somatic cell count

Besides impact on the microbiological quality of milk, linked to the transfer of infectious germs into milk (some of which, like *Streptococcus agalactiae*, *Staphylococcus aureus* and *Escherichia coli* can be pathogenic to man), mastitis can also induce major changes in the S&G milk composition (Pirisi et al., 1999a,b; Albenzio et al., 2004; Bianchi et al., 2004; Leitner et al., 2004; Haenlein, 2002).

The normal level of somatic cells in non-mastitic S&G milk is characterized by great variability. It is particularly high in the colostral period and at the end of lactation, but may be influenced by various factors such as the age of the animal, its level of production, stress, the sanitary state of the animal, etc. Somatic cells contained in milk can be grouped into three types: epithelial cells, blood cells and cytoplasmic particles. The proportions of these different cell categories vary during the course of lactation and depend also on the sanitary state of the animal. During an episode of mastitis, the immune defences of the udder are activated, polynucleated leukocytes pass from the blood into the mammary gland in large numbers, and the number of somatic cells in the milk increases. The processes of filtering and synthesis of milk components are modified, bringing about imbalances in milk composition. The filtering capacity of the mammary gland is stimulated, provoking mainly an increase in soluble non-casein protein content, and that of some mineral elements, in particular sodium, while on the other hand a reduced synthesis in the udder causes reduction in lactose content. The latter is particularly evident in sheep milk. The pH value is also altered and is higher in mastitic milk than in normal milk, resulting in poor milk aptitude for rennet coagulation and cheese making. The effect of milk SCC on the sensory characteristics of cheeses is less well-documented (Coulon et al., 2004).

5.3. Presence of inhibiting substances

Substances that are capable of slowing down or inhibiting the development of lactic acid bacteria, are blocking the fermentation processes in cheese making, and constitute a health risk to the consumer. They include residues of pharmacological, antibiotic, detergent and disinfectant substances. The treatment of mastitis with antibiotics and sulfa drugs is one of the main causes for the presence of inhibiting substances in milk. Pesticides, too, and certain mycotoxins may reach the milk when the animal ingests contaminated feed. Milk and its products destined for human consumption must be free of inhibiting substances and this is reflected in strict regulations of milk control systems and incentive payment programs.

6. Physical and chemical quality

From a quantitative standpoint, cheese is mainly composed of proteins and fats as well as minerals, water, etc., therefore an adequate protein and fat content in the milk used as the raw material for cheese making is of particular importance in defining its chemical quality, as it has a determining effect on cheese yield. There are no official and global regulations on fat and protein contents of milk other than minimum level requirements, and every regional industry has its own specifications according to market conditions and needs. Apart from these, certain physical and chemical parameters are important quality monitors, such as freezing point, which makes it possible to identify fraud due to the addition of water to the milk (Brathen, 1983; Antunac et al., 2001), or the pH value, which can be used as a pointer to the hygienic quality of the milk. Although criteria of milk quality have always referred mainly to fat, protein, solids contents, many inter-professional laboratories, which deal with milk analyses, have long since also introduced identification of the freezing point, the pH value and lactose content. Lipolysis, which corresponds to the enzymatic hydrolysis of fat, is another criterion sometimes used as an indicator of the organoleptic quality for goat milk. Indeed goat flavour and flavour defects in milk and in soft white cheese are well-correlated with the level of lipolysis in milk (Morgan et al., 2001).

7. The main quality payment systems

Since the principal use of S&G milk is cheese making, evaluation of its quality is of fundamental economic

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Table 3
Milk quality incentive program of US Land O'Lakes cow dairy company used as model by US goat dairies (Haenlein, 2000)

Deduct 10 ¢	Deduct 5 ¢	Quality standards	Premium 10 ¢	Premium 20 ¢	Premium 40 ¢	Premium 50 ¢
>101,000	51–100,000	Plate loop count (PLC)	<20,000	<10,000	<5,000	<3,000
>201,000	101–200,000	Preliminary incubation (PI)	<40,000	<30,000	<20,000	<10,000
>751,000	601–750,000	Somatic cell count (SCC)	<300,000	<225,000	<150,000	<125,000
<530	<530	Cryoscope	530–550	530–550	530–550	530–550
<90	<90	Farm score points	>90	>90	>90	>90

Cumulative deductions will be made for PLC, PI and SCC. Milk will be rejected if it tests positive for contents of antibiotics and other inhibiting substances. Acceptable SCC for goat milk has been kept by special ordinance at 1,000,000. Additional filtration tests for sediment contents are also routine made.

importance. Systems of quality payment for S&G milk are applied only in some European Countries and particularly where the S&G sector is well-developed (France, Spain, Italy, Greece, Portugal, Norway and The Netherlands). Outside of Europe, systems of quality payment for S&G milk are implemented on a regional scale in USA, Canada, New Zealand, Israel and Taiwan (Dubeuf and Le Jaouen, 2005; Haenlein, 2000). An example for a quality payment system patterned by individual processing companies after that used by cow dairies in the USA is given in Table 3.

Historically, all these systems take into consideration several parameters such as protein and fat content, and microbiological quality. When such a system is implemented, this means that under normal circumstances a basic price is determined for milk of standard quality, which is used as a basis for applying a bonus or penalty related to each parameter of the milk in question.

Inside the EU, the situation varies greatly between countries. Some examples of quality payment systems are presented in Tables 4–10. Quality payment for S&G milk has long been organised in France, except in Corsica where it is of recent date, and in Italy, particularly in Sardinia. In Spain it has been developed more recently with large differences between the regions, while in Greece it has only just been implemented on a small scale. Usually the medium–big industries are really involved in quality payment for milk because of their quality policy and their presence on the world market. Typical examples of this are the Roquefort basin in France, Pecorino Romano in Sardinia and Manchego in Spain. In all other cases, the quality payment systems are limited. For instance, in Spain, there is competition between the local companies and the French or Dutch companies for goat milk collection. The application of quality payments, in this case, is strongly dependent on the market situation: when in France or The Netherlands the demand for goat milk is high, quality payment is not enforced, while more restrictive conditions are applied in the case of over-production. So the conditions in this sector remain precarious because of a lack of strong contractual relations between the farmers and the dairies.

Recently in Sardinia, the Regional Government established that a payment system for S&G milk quality needs to be individualized with the parameters defined by a joint committee (farmers, dairy industries and Regional Government). The base price has to be determined on the basis of the market price for the four most important Sardinian cheeses, also taking into account the costs of production and the yield of the different cheese types.

The organisation of a quality payment system requires some prerequisites: a qualified laboratory to make the analyses, the logistics to collect the samples and an interprofessional organisation that guarantees the independence of the analyses. A technical service to assist the farmers in the improvement of milk quality still needs to be provided. Sometimes the analysis is carried out by the dairy companies themselves, without any guarantee for the farmers. In this case the quality payment could be used as a tool to favour some producers (i.e. the most competitive producers or those near to the dairy). The S&G dairy sector is characterized by the small size of farms, often located in large areas and presenting a wide diversity of production systems, which does not make the organisation of a good payment system easy. This is the main reason why these systems are still limited in several countries.

8. Discussion

There is such variability in the situations (production system, level of production and collection of the milk, qualitative criteria and thresholds applied), that it is impossible to make any overall statement at world level, concerning the efficiency of the payment criteria applied to milk quality (Dubeuf and Le Jaouen, 2005).

We will give here an example of goat milk collection in France, in the main region of production (Poitou-Charentes area). This can help to better understand the impact on milk characteristics of a payment system

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Table 4
Payment for goat milk according to the quality in region Poitou-Charentes area, France, specifications 2001 (data from Bureau Regional Interprofessionnel du Lait de Chèvre de Poitou-Charentes, France)

	Bacterial count (CFU/ml)	Points	Somatic cell (cells/ml)	Points	IgG (g/l)	Points	Inhibitors (presence/absence)	Points	Lipolysis (Meq/100 g FM)	Points	Cryoscopy (percentage of water added)	Points
Classification of milks	Arithmetic average		Arithmetic average									
Milk of reference R	<50,000	0	<1,000,000	0	<0.6	0	First time	8	<1.77	0	Identification of all results >2%, results <2% are returned to 0%	One point per percentage of watering
Category A	50,001–100,000	3	1,000,001–1,250,000	0	0.6–0.8	0	Second time	16	>1.77	5		
Category B	100,001–200,000	20	1,250,001–1,500,000	1	0.8–1	10	Third time	75				
Category C	>200,000	50	1,500,001–2,000,000	3	>1	50						
Category D			>2,000,000	5								
Number of analyses per month	3		3		1–3 (2 from September–March)		3		1 (March–September)		3	
Milk concerned	Month		Month		Month		Month		Month		Month	

Value of one point: 0.30 Euro cents. For protein content: price of the differential gram (reference 28 g/l, arithmetic average of three analyses/month), 0.95 Euro cents/g. For fat content: price of the differential gram (reference 33 g/l, arithmetic average of three analyses/month), 0.35 Euro cents/g.

Table 5
Quality payment system for goat milk in Spain, specifications 2000–2005 (data from FORLACTARIA/AGASUR dairies)

Milk composition
+€0.004 l^{-1} for each gram of fat
No payment on protein

Bacteriological quality
<50,000: +€0.024 l^{-1}
50,000–150,000: +€0.012 l^{-1}
150,000–500,000: +€0.006 l^{-1}
>500,000: penalization according to the prejudice

Somatic cell count
FORLACTARIA: penalization of €0.006 l^{-1} when SCC >1,000,000 (cells/l)
AGRASUR: no payment on SCC

Inhibitors: penalization
Cooling premium: €0.04 l^{-1}

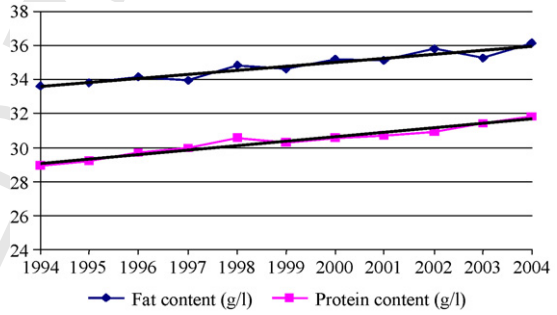

Fig. 1. Evolution of fat content (g/l) and protein content (g/l) of goat milk collected by dairies in Poitou-Charentes area, France, between 1994 and 2004. The annual value corresponds to the arithmetical mean of the monthly values weighted by the quantity of milk from 3200 flocks in 1994 and from 2300 flocks in 2004 (Laboratoire Interprofessionnel Laitier du Centre-Ouest, 1994–2004).

related to quality. Data are available over several years for this case. The system of goat milk production in this zone has changed with time but can be considered as stabilized. The payment criteria for milk collected by dairy processors has existed for a long time, with a regional system of payment (Table 4), that has been completed and standardized since 2001. For protein and fat content (in g/l of milk) a regular increase (Fig. 1) can be noted between 1994 and 2004, with an average annual increase of +0.86% for protein content and +0.68% for fat content. Concerning the bacterial count (Fig. 2), the decline is almost constant, being between 1994 and 2004 of the order of −10.8% per year for the annual arithmetical average for milk collected in this zone (and 17.7% between 2000 and 2004) (from data of the Laboratoire Interprofessionel Laitier du Centre Ouest). There is a good reason to believe that such results would not have been obtained if these incentive criteria for quality pay-

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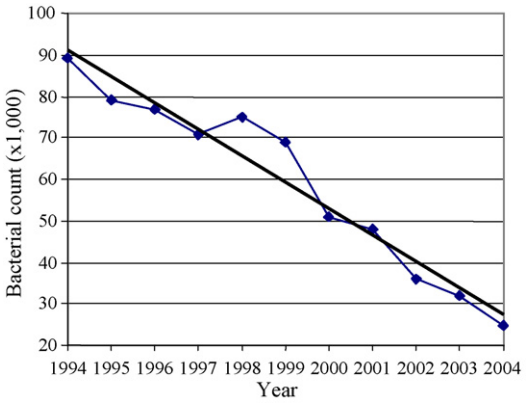

Fig. 2. Evolution of bacterial count (CFU/ml) of goat milk collected by dairies in Poitou-Charentes area, France, between 1994 and 2004. The annual value corresponds to the arithmetical mean of the monthly values weighted by the quantity of milk from 3200 flocks in 1994 and from 2300 flocks in 2004 (Laboratoire Interprofessionnel Laitier du Centre-Ouest, 1994–2004).

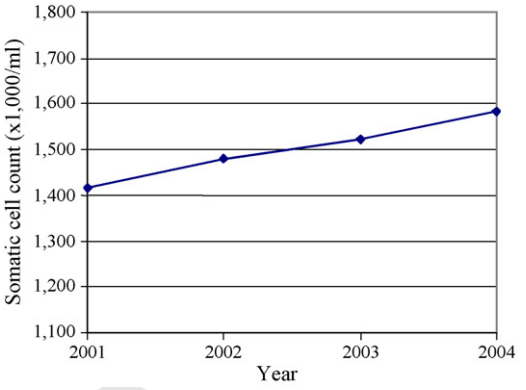

Fig. 3. Evolution of somatic cell count (cell/ml) of goat milk collected by dairies in Poitou-Charentes area, France, between 2001 and 2004. The annual value corresponds to the arithmetical mean of the monthly values weighted by the quantity of milk from 2500 flocks in 2001 and from 2300 flocks in 2004 (Laboratoire Interprofessionnel Laitier du Centre-Ouest, 1994–2004).

ment of the milk had not been set up. Concerning SCC, on the contrary, we can observe (Fig. 3) that between 2001 and 2004 the average annual level increased (by around +3.6% per year), which is contrary to what is desired for this quality criterion. Breeders and technicians have no real explanation for this phenomenon, which perhaps could be related to the intensification of milk production and the increase in milk yield.

These results prompt two conclusions:

Firstly, to obtain the desired changes, it is better to establish a real incentive, i.e. a benefit above a certain threshold, which is the case in the example for fat and protein content, rather than a system of allowances if the optimum level is not reached (SCC in this example).

Secondly, and this is most important, it is necessary that there should be technical, individual or collective and effective solutions for the breeders that are economically viable with their system of production, as well as a means of distribution of techniques and technical advice for the breeders.

In the previous example, these conditions are properly met for fat and protein contents and for the bacteria count (program of genetic selection, advice on nutrition and general hygiene) but not for SCC (no effective technical advice exists for European breeders).

The breeding of dairy S&G has developed a great diversity in the animal populations and consequently, in the productive traits of the flocks. There are many S&G

Table 6
Quality payment system for goat milk in Norway (Kalantzopoulos et al., 2004)

Class	Bacterial count (CFU/ml)	Somatic cells (millions)	Sensory evaluation	Inhibitors and control of water adjunction	Abnormal milk
Elite	≤20,000	≤1,500,000	No off-flavours		
1	21,000–30,000	1,500,000–1,750,000	No off-flavours		
2	31,000–50,000	1,750,000–2,000,000	Significant off-flavours		
3	>50,000	>2,000,000	Strong off-flavours		
Number of analyses	Two each month	Two each month	One each month	Freezing point, twice a year; inhibitors, every delivery	
Management of variations and null payments					
Payment			Elite: extra price Classes 2 and 3: reduction in price relative to increasing f.p. Inhibitors: no payment and "fine" Abnormal milk: no payment		

Norway has the same governmental hygienic requirements as the EU Directive 92/46.

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Table 7
Quality payment system for sheep milk in the Roquefort area, France, Campaign 1998 (data from General Confederation of sheep's milk producers and manufacturers of Roquefort)

(a) Milk bacteriological quality (score grid)

	Bacterial count (CFU/ml)		
Coliforms (CFU/ml)	<100,000	100,000–250,000	>250,000
≤500	3	2	1
501–2,500	2	1	1
>2,500	1	0	0

Milk bacteriological quality (classification grid)				Penalties
Classification	Total monthly points			
	Three controls	Two controls	One control	
A	9–8	6–5	3	None
B	7–6	4	2	−€0.03
C	≤5	≤3	1–0	−€0.07

(b) Milk butyric quality

Spores/l	Grade
≤1,300	3
1,301–2,400	2
>2,400	1

Classification	Total points for four controls	Penalties
A	12–10	None
B	9–7	−€0.03
C	6–4	−€0.07

(c) Somatic cell count

Somatic cells/ml	Grade
<1,000,000	3
1,000,000–1,500,000	2
>1,500,000	1

Classification	Total monthly points			Penalties
	Three controls	Two controls	One control	
A	9–8	6–5	3	None
B	7–6	4	2	−€0.03
C	≤5	≤3	1	−€0.07

The milk is also checked for the presence of *Listeria monocytogenes*. These checks are only made for producers using well-conserved forages. These checks are made twice a month from December to end of April. The results of the four last checks are considered (generally 2 consecutive months).

Table 8
Quality payment system for sheep milk in Pyrénées-Atlantiques, France, specifications 2005 (data from Interprofession laitière ovine des Pyrénées-Atlantiques)

(a) Milk bacteriological quality

Coliforms (CFU/ml)	<100,000	100,001–250.000	>250,000
≤500	3	2	1
501–2,000	2	1	1
>2,000	1	0	0

Classification	Total monthly points			Penalties
	Three controls	Two controls	One control	
A	9–8	6–5	3	None
B	7–5	4	2	−€0.0076
C	4–3	3–2	1	−€0.0305

(b) Milk butyric quality

Spores/l	Grade
≤1,000	3
1,000–2,000	2
>2,000	1

Classification	Total points for three controls	Penalties
Super A	9	+€0.061
A	8	None
B	5–7	−€0.0015
C	3–4	−€0.0045
Super C	Three analysis >5,000	−€0.015

(c) Somatic cell count

Somatic cells/ml	Grade
<1,000,000	3
1,000,000–1,500,000	2
>1,500,000	1

Two checks a month with an effect on the price. Chemical composition: the milk is paid according to fat and protein content. Standard, 75 g of fat and 55 g of protein; fat, ±€0.0046 kg^{-1}; protein, ±€0.0069 kg^{-1}.

breeds deriving from local breeds or populations. In most less-developed countries the milk yield per animal is low and the farm equipment is rudimentary: flock size can be very low (mixed farms, S&G raised together) or very large (pastoral and nomadic systems, flocks reared by one or more families). In developed countries, which are those concerned at present by payment for the milk according to qualitative criteria, the flock size averages between 100 and 300 sheep, and between 30 and 150 goats. Extensive management systems still play a very important role in many developed countries (i.e. Greece, Spain, Portugal, etc.) (Dubeuf et al., 2004a,b).

The economic conditions of the production and marketing of milk, and the strict application of sanitary regulations (European regulations) have changed the production systems considerably in some countries such as France, Italy, Spain, etc. The flocks have become big-

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Table 9
Quality payment system for sheep milk in Greece (Kalantzopoulos et al., 2004)

Final price[a] = basic price + fat-based value + protein-based value + quality premium + quantity premium − water penalty − antibiotic presence penalty	
Basic price	€0.76–0.81 kg^{-1}
Fat (%)	
<5.9	−€0.03 kg^{-1} for each 0.1 fat to a limit of −€0.3 kg^{-1}
6.5–6.80	None
>6.9	+€0.03 kg^{-1} for each 0.1 fat to a limit of +€0.3 kg^{-1}
Protein (%)	
≤5.4	−€0.3 kg^{-1}
5.5 ≤ protein% < 5.8	None
Protein > 5.9	+€0.3 kg^{-1}
Quality[b] premium	
AA (≤200,000 CFU/ml)	€0.3–0.45 kg^{-1}
A (200,000–500,000 CFU/ml)	€0.015–0.3 kg^{-1}
B (500,000–1,500,000 CFU/ml)	€0.06–0.09 kg^{-1}
G (>1,500,000 CFU/ml)	€0 kg^{-1}
Quantity premium[c]	Maximum €0.06 kg^{-1}

[a] Price of milk is determined on the basis of the average of four analyses in each month.
[b] The quality classification of milk is determined on the basis of bacterial count (CFU/ml), with the presupposition that the antibiotic residue must be null and the value of freezing point must be less than −0.550 °C in each sample.
[c] Quantity premium varies with the region and the annual delivered quantity of milk.

ger, the facilities have been improved, animal nutrition has been rationalised and consequently the milk yield by S&G has risen. At the beginning this situation led to a general decrease of fat and protein content in milk due to dilution of the useful total solids in milk. It has been possible to compensate partially for this decrease in protein and fat content (g/l) by the implementation of selection programs. Only some breeds (i.e. Awassi, Lacaune, Sarda for sheep and Alpine, Saanen for goats) have been specialized for milk production and are submitted to an efficient selection program, to the detriment of local breeds, which can be threatened with disappearance. The new market trends, which are increasingly receptive towards traditional products, could be an excellent opportunity to preserve the biodiversity and traditional breeds of the S&G dairy sector.

We have not discussed the case of those regions where milk is principally used for family or local consumption, because they are not involved in incentive payment systems. Nevertheless, in several cases in these regions, although it can also be the case elsewhere, there are potentially serious hygienic problems (i.e. brucellosis, tuberculosis and pathogenic bacteria), and heat treatments for the milk have been recommended or required in order to control possible dangers to human health.

When there are no evident risks for human health, the use of raw milk is prescribed or advised by the PDO specifications for most traditional cheeses. Several studies (Lau et al., 1991; Pinna et al., 1999; Pirisi et al., 1999a,b) have pointed out that the use of raw milk influences the chemical composition during ripening and the sensory properties of the cheeses favourably, especially for cheeses with a long ripening time, it allows the expression of the production systems, and the link to the region of production. The specific native microflora and native enzymes, preserved by the use of raw milk, combine to maintain certain specific characteristics of the products. A very low bacterial count due to heat treatments can be detrimental for the native lactic microflora of the milk. The objective of bacteriological controls would be to exclude pathogenic and non-lactic bacteria. The method of presently used routine enumeration (Bactoscan) does not allow differentiation of the milk flora (lactic, psychrotrophic, pathogenic bacteria). The hygienic option of precaution for the consumer using pasteurization or UHT treatment to decrease the microbial flora of the milk will also decrease the technologically useful flora and could be inevitable at the world level. In the case of traditional cheeses, this may have to be accepted, but is compensated by the use of traditional technological processes (paste rennet or starter from whey), which enable the typical character and originality of the traditional cheeses. A good approach when defining the limits for bacterial counts is to take in account the type of cheese that has to be produced. A fresh or soft cheese with a short ripening time is certainly more sensitive from the microbiological point of view than a cheese with a medium or long ripening time.

The control of hygienic quality is not only related to the quality payment system. Simplified methods based on the Hazards Analysis of Critical Control Points (HACCP) method have already been used for daily control by the farmer himself. Although these methods require proper training, they have been applied in several situations, for instance in France and particularly on farms that make cheese and where the quality payment system is not applied directly.

The concept of quality, in any case, has recently evolved considerably: animal welfare, the farm environment and the general organization of production is more and more taken into consideration. Initiated in the cow milk sector, farm labels with economic incentive effects

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Table 10
Proposed quality payment system for sheep milk in Sardinia (Italy), specifications 2006 (data from Sardinian Regional Breeders Association)

	Premium and penalties (initial stage) Euro cents	Increase/decrease	Premium and penalties (range) Euro cents
Protein[a] (%)			
<4.70	−2.066	−0.01	−0.004
4.71–5.55	None	−0.01	−0.024
5.56–5.75	None	None	None
5.76–6.79	None	+0.01	0.021
>6.80	+2.169	–	–
Fat (%)			
<5.40	−1.549	−0.01	−0.003
5.41–6.20	None	−0.01	−0.019
6.21–6.60	None	None	None
6.61–7.59	None	+0.01	+0.019
>7.60	+1.911	–	–
Bacterial count (CFU/ml × 10^3)			
<500	+0.516	−100	+0.103
501–1,000	None	−100	+0.103
1,001–1,500	None	None	None
1,501–3,000	None	+100	−0.052
>3,000	−1.549	–	–
Somatic cells (cells/ml × 10^3)			
<500	+0.516	−100	+0.103
501–1,000	+0.258	−100	+0.052
1,001–1,300	None	−100	+0.086
1,301–1,700	None	None	None
1,701–2,500	None	100	−0.065
2,501–3,000	−0.516	100	−0.052
>3,000	−1.033	–	–

Example of calculation: milk with 5.54% of protein, 6.65% of fat, 400,000 (CFU/ml) of bacterial count and 1,800,000 of somatic cells/ml, will have in total a premium of €0.536; −€0.048 for protein, +€0.095 for fat, +€0.619 for bacterial count and −€0.13 for somatic cells +€0.536.
[a] Premium for protein is cancelled if somatic cells are up to 3,000,000.

would enable a global quality of the farm to be improved. These factors are beginning to be included in the PDO cheese specifications.

As indicated above, the conditions of payment for S&G milk according to quality criteria are very variable, and are related to the countries, regions, systems of production and products.

The criteria used currently are based on methods which present the advantage of being fast and inexpensive. They also present, however, the inconvenience of being rather approximate. Clarification would be desirable with specification of some criteria. These could mainly concern: the milk proteins, with measurement of the casein content, since the casein level is directly correlated to the cheese yield; the fat content, also considering those fatty acids of nutritional interest (i.e. CLA); the bacterial count, drawing a distinction between psychrotrophic and coliforms and lactic bacteria; the SCC, estimating only leukocytes linked to mastitis thanks to the use of the latest methods.

This will require follow-up studies, adaptation of the methods and development of analytical methodologies, to ensure that results are reliable and inexpensive to achieve.

9. Conclusions

The situation of the S&G dairy sector is very variable and different around the world, especially between the developed and undeveloped countries. For this reason a complete analysis of the production conditions and the payment systems for S&G milk is certainly difficult. In this review, we have shown that a few countries, particularly in Europe, have a good situation in terms of the hygienic conditions for S&G milk production, and an international market for their products. The application of S&G milk payment systems in European countries has been directly related to the development and industrialization of the sector and it has significantly contributed to improve the quality of S&G milk and cheese. In

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developing countries, where incentive milk payments for quality do not yet exist, prophylactic and sanitary public measures are a prerequisite before efforts to develop incentive systems can be made.

In conclusion it can be stated that objective reasons exist in support of the introduction of quality payments for S&G milk. It is opportune, however, to define the optimal procedures and frequency of sampling and analyses. The parameters which should be considered and their economic weight have to be established. At the same time it appears to be necessary to develop and improve the technical assistance given to breeders so that they can adopt the most suitable measures in order to raise the quality of their milk within economic limits and potentials at the farm level.

Uncited reference

Directive 94/71/EC (1994).

References

Albenzio, M., Caroprese, M., Santillo, A., Marino, R., Taili, L., Sevi, A., 2004. Effects of somatic cell count and stage of lactation on the plasmin activity and cheese making properties of ewe milk. J. Dairy Sci. 87, 533–542.

Antunac, M., Havranek, J., Samarzua, D., 2001. Freezing point of goat milk. Milchwissensch 56, 14–16.

Berger, Y., Billon, P., Boquier, F., Caja, G., Cannas, A., McKusick, B., Marnet, P.-G., Thomas, D., 2004. Principles of Sheep Dairying in North America, vol. A 3767. Cooperative Extension Publisher, University of Wisconsin, Madison, WI, 151 pp.

Bianchi, L., Bolla, A., Budelli, E., Caroli, A., Casoli, C., Pauselli, M., Duranti, E., 2004. Effect of udder health status and lactation phase on the characteristics of Sardinian ewe milk. J. Dairy Sci. 87, 2401–2408.

Brathen, G., 1983. Freezing point of goats', buffaloes' and ewes' milk. In: Measurement of Extraneous Water by Freezing Point, Test. International Dairy Federation Bulletin No. 154, p. 6.

Centre National Interprofessionnel de l'Economie Laitière, 2005. L'économie Laitière en Chiffres (Data of Dairy Economy), 2005 ed. Interprofessional National Centre of Dairy Economy, Paris, France, p. 67 (in French).

Coulon, J.B., Delacroix-Buchet, A., Martin, B., Pirisi, A., 2004. Relationships between animal management and sensory characteristics of cheeses: a review. Lait 84, 221–241.

Directive 94/71/EC, 1994. Directive amending Directive 92/46/EEC laying down the health rules for the production and placing on the market of raw milk, heat-treated milk and milk-based products. Off. J. Eur. Community L368, 33–37.

Dubeuf, J.P., Couzy, C.H., Ligios, S., 2004a. L'organisation du développement pour l'élevage ovin laitier ovin et caprin; étude dans quelques régions d'Europe du Sud. Development organisation for sheep and goat dairy farming: study in some southern European regions. Options Méditerranéennes. Série A, Séminaires Méditerranéens 61, 41–48 (in French).

Dubeuf, J.P., Le Jaouen, J.C., 2005. The sheep and goat dairy sectors in the European Union: present situation and stakes for the future. In: Future of the Sheep and Goats Dairy Sector. 1. Panorama of Sheep and Goat Dairy Sectors. International Dairy Federation Bulletin No. 501, pp. 1–7.

Dubeuf, J.P., Morand-Fehr, P., Rubino, R., 2004b. Situation, changes and future of goat industry around the world. Small Rumin. Res. 51, 165–173.

FAOSTAT data, 2005. www.fao.org/faostat/ (last updated on February 2005).

Haenlein, G.F.W., 1993. Producing quality goat milk. Int. J. Anim. Sci. 8, 79–84.

Haenlein, G.F.W., 2000. The concept of milk quality in the USA. In: Proceedings of the International Goat Conference, vol. 2, Tours, France, May 15–18, pp. 867–868;
Haenlein, G.F.W., 2000. The concept of milk quality in the USA. Int. J. Anim. Sci. 16, 5–8.

Haenlein, G.F.W., 2002. Relationship of somatic cell counts in goat milk to mastitis and productivity. Small Rumin. Res. 45, 163–178.

Haenlein, G.F.W., Wendorff, W.L., 2006. Sheep milk. In: Park, Y.W., Haenlein, G.F.W. (Eds.), Handbook of Non-Bovine Mammals. Blackwell Publishing, Ames, IA, pp. 137–194.

Institut de l'Elevage, 2005. L'année Économique Caprine (The Economic Year of Goat Sector), no. 355, vol. 4–10 (in French).

Kalantzopoulos, G., Dubeuf, J.P., Vallerand, F., Pirisi, A., Casalta, E., Lauret, A., Trujillo, T., 2004. Characteristics of sheep and goat milks: quality and hygienic factors for the sheep and goat dairy sectors. In: International Dairy Federation Bulletin No. 390, pp. 17–28.

Laboratoire Interprofessionnel Laitier du Centre-Ouest, 1994–2004. Annual Reports of Activity (Unpublished). Interprofessional Dairy Laboratory of Centre-West, Surgeres, France.

Lau, K.Y., Barbano, D.M., Rasmussen, R.R., 1991. Influence of pasteurization of milk on protein breakdown in Cheddar cheese during aging. J. Dairy Sci. 74, 727–740.

Leitner, G., Merin, U., Silanikove, N., 2004. Changes in milk composition as affected by subclinical mastitis in goat. J. Dairy Sci. 87, 1719–1726.

Morgan, F., Bodin, J.P., Gaborit, P., 2001. Lien entre le niveau de lipolyse du lait de chèvre et la qualité sensorielle des fromages au lait cru ou pasteurisé (link between the level of lipolysis in goat milk and sensorial quality of cheeses from raw or pasteurized milk). Lait, 743–756.

Pinna, G., Pirisi, A., Piredda, G., Addis, M., Di Salvo, R., 1999. Effetto della termizzazione del latte sul formaggio DOP Fiore Sardo. 2. Andamento della lipolisi nel corso della maturazione. Effect of milk thermization on Fiore Sardo PDO cheese. 2. The lipolysis progress during ripening. Sci. Tecn. Latt.-Cas. 50, 366–377 (in Italian).

Pirisi, A., Gaspard, C.E., Piredda, G., Jaubert, A., Ledda, A., 1999a. Relation entre CCS et les caractéristiques du lait de brebis et de chèvre. Influence of SCC on sheep and goat milk characteristics. In: Milking and Milk Production of Dairy Sheep and Goats. EAAP Publication No. 95. Wageningen Pers, Wageningen, The Netherlands, pp. 495–500 (in French).

Pirisi, A., Pinna, G., Papoff, C.M., 1999b. Effetto della termizzazione del latte sul formaggio DOP Fiore Sardo. 1. Caratteristiche fisico-chimiche. Effect of milk thermization on Fiore Sardo PDO cheese. 1. Physico-chemical characteristics. Sci. Tecn. Latt.-Cas. 50, 353–366.

Pirisi, A., Sanna, A., Caria, A., 2000. Raw materials: quality and pricing. In: International Dairy Federation Bulletin No. 354, pp. 12–17.

Raynal-Ljutovac, K., Gaborit, P., Lauret, A., 2005. The relationship between quality criteria of goat milk, its technological proper-

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Please cite this article in press as: Pirisi, A. et al., Basic and incentive payments for goat and sheep milk in relation to quality, Small Rumin. Res. (2006), doi:10.1016/j.smallrumres.2006.09.009

ties and the quality of the final products. Small Rumin. Res. 60, 167–177.

Thomas, D., Haenlein, G.F.W., 2004. Panorama of the goat and sheep dairy sectors in North America. In: Proceedings of the Future of Sheep and Goat Dairy Sectors Conference, Zaragoza, Spain, October 28–30, p. 6.

Tsiboukas, K., Vallerand, F., 2004. Formes de filières lait-fromage de petits ruminants en Grèce et leurs perspectives de développement. Types of small ruminant dairy-cheese "filières" in Greece and outlooks on their future. Options Méditerranéennes. Série A, Séminaires Méditerranéens 61, 307–315 (in French).

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