

Part III

Improving particular milks and milk-based products

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Improving organic milk

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Abstract: The chapter discusses the key factors influencing the quality of organic milk and the management and husbandry techniques available on dairy farms for improving quality. The key factors include the requirement to feed high forage diets, the importance of dietary energy, grazing strategies for clover-based pastures and minimising health problems. Cropping options for improving the nutritive value of organic rations and the influence of the season of calving on milk quality are also reviewed.

Key words: organic dairy systems, organic milk, feed energy, high forage diets, improving the quality of organic milk.

11.1 Introduction

The major differences in milk quality between organic and conventional systems are attributable to the variation in the type and quality of feeds that are included in the diet of the dairy cow, including the production of organic milk from high forage diets. One of the biggest challenges for the organic dairy farmer is to implement and manage a system that will ensure a consistent production of quality milk throughout the year, from diets that often include a less varied range of constituents compared with those used in the formulation of diets for conventional herds. As forages differ widely in nutrient balance and consistency when compared with concentrate feeds, the quality of organic milk is potentially more variable than that of milk produced from cows in conventional systems fed diets with higher concentrate content. The key factors affecting milk quality during the year are the changes in the quality of feed available for formulating diets, the change from the grazing of fresh herbage to the feeding of conserved

forages, the stage of lactation and the influence of the calving pattern on the season of peak milk production.

The production of organic milk is influenced by a number of key factors, including both the standards defined for organic milk production and the need of both the liquid and processing markets to meet consumer demands and expectations. In addition the influence of the type of system, climatic conditions and complexity of the cropping strategy to produce high quality feed for the dairy herd also affects both the level of production and the quality of organic milk. Organic dairy systems vary in size and their approach to management and husbandry options, with a range of systems managed on different farms both within and between different countries. Surveys of organic dairy farms show that, in relation to milk quality, there are large differences between individual farms that are attributable not only to genetic differences in the herd profile but also to management and husbandry factors. While many farms manage to consistently produce high quality milk throughout the year, others record seasonal variations, including the production of milk that is below the standards required for both the liquid and processing markets. For the majority of organic farms the aim of producing quality milk needs to be achieved within a system that also maximises profitability to provide a satisfactory financial return on the capital that has been invested in the system.

Organic dairy systems include the more extensive and sustainable systems aiming for a high level of nutrient self-sufficiency and efficient nutrient utilisation within a management strategy that requires a more complex crop rotation to produce both forage and concentrate feeds. Other systems aim to maximise the output of milk and financial viability per hectare by only growing forage crops in a basic rotation, maintaining a higher stocking density, and purchasing significant quantities of concentrate feeds to ensure diets fully meet the nutritional requirements of the dairy cow. For many farmers the most practical option is a compromise between the above contrasting systems, avoiding both the limitations of a fully self-sufficient system and the total reliance on the purchase and importation of concentrate feeds that vary in both availability and price.

The chapter will address many of the factors that influence the quality of organic milk and identify options for improving quality within the standards defined for organic milk production, while ensuring the system achieves financial viability.

11.2 The key factors affecting the quality of organic milk

11.2.1 The limitations of the organic standards

The standards defined for organic milk production require a minimum inclusion rate of 60% forage in the total diet. Depending on the stage of lactation and also the availability and cost of different feeds used for formulating the diets, forage can contribute up to 100% of the total feed. Compared with rations formulated

for conventional herds, there is a more limited range of ingredients that can be included in organic rations and a greater risk of nutrient imbalance. Both these factors have led to a number of studies showing nutritional deficiencies and an increased risk of lower milk protein concentrations to be a problem on some farms, particularly during the early lactation period (Weber *et al.*, 1993; Weller and Bowling, 2004; Nauta *et al.*, 2006). The risk of nutritionally related problems is more critical when the level of milk production increases; forage quality decreases and both the energy density and energy–protein balance of the diet become unbalanced. Organic milk also needs to be produced from systems that utilise environmentally sustainable production methods, efficiently recycle nutrients within the system and have a low use of non-renewable resources (Zollitsch *et al.*, 2004).

As shown by the incidence of contagious sub-clinical mastitis in some herds, managing herd health status without the routine use of long-acting antibiotics has been found to be more challenging on some organic dairy farms and has led to increased health problems and lower quality milk, particularly when the use of alternative treatments has not been widely adopted.

11.2.2 The implications of meeting the requirements of the commercial market

The challenge for organic dairy systems is not only to produce milk within defined standards from a system that is financially viable and minimises environmental impact, but also to meet the demands of the commercial market. Consumers require a supply of fresh milk on a regular basis, therefore a key objective in the management of the herd is to sustain a consistent output of high quality milk throughout the year. As the availability and quality of the different grazed and conserved forages change significantly during the year, the challenge of providing balanced diets for the dairy cow requires an evaluation of the cropping strategy and other management options to meet the requirements of the commercial market.

11.2.3 Limitations on the individual organic dairy farm

Studies have shown wide variations in the proportion of organic milk that is produced from the forage component of the diet, with large differences recorded between organic farms in how efficiently they utilise forage and their level of dependency on concentrate feeds to achieve optimal yields of high quality milk. These results suggest that on many individual farms there is scope to improve the management of the herd in relation to the type and quality of forages that are produced, the strategies used for grazing and forage conservation, and the efficiency with which the forages are utilised in relation to the formulation and feeding of high forage diets. Large differences have also been recorded between farms in their approach to husbandry practices and the management of the herd, indicating that not only diet but other key factors, including genetics and

environmental issues, may also be limiting the potential of the herd to maximise the production of quality milk.

The effect of the standards defined for organic milk production may be more critical for farms in less favourable climatic areas that are unable to grow a wide range of crops, as their ability to produce quality milk from nutritionally balanced diets is more limited unless high quality herbage can be produced in adequate quantities, both during the grazing season and as conserved forages for feeding during the winter period of housing. The increased complexity of establishing and maintaining a more complex cropping strategy to ensure high quality feed is available throughout the year may not be either practical or financially viable on smaller farms with limited labour and machinery resources, unless the cost of employing contractors can be justified.

11.3 Management and husbandry techniques to improve the quality of organic milk

11.3.1 The nutritional balance of the diets

Maintaining the production of quality milk is dependent on maximising the intake of high quality diets and achieving compatibility between the genetic merit of the cow and nutritionally balanced diets that are appropriate for the different stages of the lactation cycle. The plane of nutrition is a critical factor influencing both the composition and the processing properties of milk, with adequate feed energy essential in the production of milk with an acceptable protein concentration and a milk fat to protein ratio < 1.5 . In a review of 13 studies, Emery (1978) found increasing feed energy intake and milk protein concentration to be positively correlated and attributable to the increasing proportion of concentrate feeds in the diet. Sporndly (1989) reported an increase of 10 MJ of metabolisable energy (ME) per day, increasing milk protein content by 0.03–0.05% points. As forage contributes between 60 and 100% of the total feed in the diet of the organic dairy cow, one of the major challenges is to formulate high forage diets with an adequate energy concentration. As the energy value of the majority of forages is generally lower (< 11 MJ of ME per kg DM) than that of concentrate feeds (> 13 MJ of ME per kg DM), the strategy on organic dairy farms has to focus on ensuring that sufficient quantities of high quality forages are not only grown but also consumed in sufficient quantities by the dairy cow throughout the year. Although grazed herbage generally has a higher energy value compared with conserved forages, a shortage of energy has been found to be a limiting factor during the grazing season as well as when diets based on conserved forages are fed. While many organic herds are able to achieve milk yields of 4000–5000 kg per cow from the forage component of the diet, others fail to reach these levels and rely on concentrate supplementation to achieve satisfactory lactation yields, indicating a need to improve the production and efficient utilisation of forages.

Achieving a satisfactory output of quality milk during the early lactation period is a major challenge for many organic dairy farmers feeding high forage

diets, with maximising energy intake the key challenge. Early lactation is inevitably a period of negative energy balance for the majority of dairy cows, and the risk of a severe deficit of nutrients will be at a maximum during the first eight weeks of lactation (Zollitsch *et al.*, 2004). This is primarily due to peak feed intake not being normally achieved until three to four weeks after the attainment of peak milk yield (Thomas *et al.*, 1999). The magnitude and length of time of the negative energy balance will be influenced to a greater extent by variability in feed intakes and increasing genetic merit, with high genetic merit cows producing an extra 6.6 kg of milk per day but increasing feed intake by only 0.8 kg per day and maintaining a negative energy balance for the first 20 weeks of lactation (Villa-Godoy *et al.*, 1988; Gordon *et al.*, 1995; Beever *et al.*, 1998).

One of the problems when formulating high forage diets is the significant changes that occur when the diets change from grazed herbage to conserved forages, temporal changes in the components and quality of grazed swards, and the significant differences between the quality and physical attributes of different conserved forages. Although supplying sufficient feed energy is the main limitation in the formulation of organic diets based on conserved forages, a shortage of protein has also been found to limit the level and quality of milk produced (Thuen *et al.*, 2002), and the potential contribution of different annual and perennial legumes (e.g. white clover, red clover, Lucerne, crimson clover, vetch) as valuable sources of feed protein needs to be recognised. On all farms there will be differences in the quality of the different forages that are available annually. Knaus *et al.* (2001) concluded that to achieve a lactation yield of 7000 kg per cow the proportion of concentrates in the diet would need to increase from 26 to 40% when low rather than high quality forage was fed, although the increased concentrate supplementation would not reduce the risk of a high body weight loss (–52 kg) through the mobilisation of body fat during the early lactation period. The benefits of improving forage quality were also reported by Kreuzer *et al.* (1996), with a 5.5% increase in metabolisable energy from 5.25 to 5.54 MJ net energy for lactation improving both the composition and processing properties of milk. Therefore, it is essential that the highest quality forages on the farm are fed to cows during the early and mid-lactation periods, with the more mature and lower quality forages fed during the less nutrient-demanding periods of late lactation and the dry period. While mixed grass and white clover swards continue to be the main forage crops for grazing and conservation, alternative forages, including high energy fodder beet and forage maize and high protein crops such as lucerne and red clover, will improve feed intake (Phipps *et al.*, 1995) and optimise the energy supply of the high forage diets for producing quality milk.

11.3.2 Organic forage cropping options

The production of milk in organic dairy systems is primarily from forage grown in mixed swards based on grass and white clover as the main species in reseeded

leys and permanent pastures. However, other high protein and high energy forage crops, grown either as a monoculture or in a mixture, have the potential to improve both the nutritional value of the diets and the quality of milk produced. These crops are fed primarily as conserved forages in silage-based diets fed during the winter period of housing but also in periods of reduced herbage availability during the grazing season. While some crops have now become more widely established, the potential benefits from other crops have not been fully exploited. As nitrogen is potentially limited within the closed nitrogen cycle on organic farms, when new crops are established a balance needs to be maintained between the different N-producing legumes and N-demanding species that are included in a crop rotation.

Higher protein forages

Different legumes are important not only for their contribution of N via fixation but also for their high intake characteristics and supply of feed protein. Compared with grasses, legumes have a higher digestibility value due to a higher cell content to cell wall ratio. While white clover is the primary legume grown in grazing swards on organic dairy farms, the potential benefits of other annual and perennial legumes as crops for conservation, including red clover, forage peas, crimson clover, lucerne and vetch, have not been fully exploited. Although a shortage of feed energy is often a problem with organic diets based on conserved forages, a shortage of protein also occurs when silage is made in the spring.

Red clover crops are grown for two to three years, primarily as a conservation crop and either as a monoculture or in a mixture with grass species, including Italian ryegrass, hybrid ryegrass, perennial ryegrass or timothy. Red clover produces high yields of a palatable feed that can improve feed intake and both the milk protein concentrations and polyunsaturated fatty acid content of milk (Al-Mabruk *et al.*, 2004). The energy value of red clover silage ranges from 9.8 to 11.4 MJ/kg of dry matter (DM), and the protein content ranges from 14 to 19%. To avoid the risk of increased oxidative deterioration of milk and reduced shelf-life when red clover silage is the sole forage included in the diet (Al-Mabruk *et al.*, 2004), the inclusion rate should be limited to 50% of the total forage component.

Lucerne is a deep-rooting perennial crop with the potential to provide a high protein forage crop in areas of low rainfall. Once established a lucerne ley will produce reliable yields over a four-year period. Crimson clover, forage peas and vetch are annual legumes whose potential to increase the protein content in both short-term leys and mixtures with whole-crop cereals has not been fully exploited. The problem of low protein when the first silage cut is taken in the spring from grass-dominant swards can be overcome by including a combination of three legumes (crimson clover, red clover, vetch) in short-term leys.

Kale is a fast-growing crop and a palatable feed with both high protein (14.7–18.8%) and high energy (11.0–12.7 MJ/kg DM) contents, which is suitable for grazing by dairy cows when the productivity of grass plus white clover leys declines from late summer onwards. However, the efficiency of utilisation of the

grazed crop can be as low as 50–60% and high intakes of kale can cause tainting of milk unless limited to 35% of feed intake.

Higher energy forages

While many organic farms rely on only grass plus legume silages as the conserved forage for feeding during the winter period, the feeding of other forages with a higher energy to protein ratio has the potential to improve the nutritional balance of the diet, increase total forage intake and avoid a sharp decline in milk quality when the diet of the herd changes from grazed herbage to silage-based diets.

Fodder beet and forage maize are both high energy crops (>11 MJ of ME/kg of DM) that can be grown within an organic rotation and their inclusion provides essential feed energy, enhances forage intake by improving the palatability of the diet and improve milk protein concentrations during the housing period. However, producing good yields of both crops is dependent on effective weed control and suitable weather conditions during the harvesting period, with a DM content of 30–35% at harvest essential to ensure that high quality maize crops with a >50% grain content are ensiled. In formulating organic diets that include either forage, it is important to note that both crops are low in both protein and mineral contents.

In addition to producing grain for feeding and straw for bedding, cereal crops can also provide additional forage energy when the whole plant is harvested and ensiled as whole-crop cereal silage at 35–45% DM and with the grain at the soft dough/soft 'cheddar' stage. Whole-crop cereals are cut three to four weeks prior to normal grain harvest and often only 16 weeks after the crop is sown. Compared with both fodder beet and maize silage, whole-crop cereal silage has a lower energy value (9–10 MJ of ME/kg DM) than either fodder beet or maize, but cereals can be more widely grown, produce consistent yields and provide palatable feed to complement high protein grass plus legume silages. Cereals also provide an effective cover crop when new grass plus clover leys are being established, with minimal weed problems compared with those found in fodder beet and forage maize crops, particularly when crops are under sown. In addition to being grown as a monoculture, cereals can be grown in mixtures with protein crops, including forage peas and vetch, leading to higher energy and protein forage and providing extra nitrogen via fixation for improving total forage production within the system.

Improving the quality of reseeded leys

Increasing the species diversity within a sward based on perennial ryegrass and white clover has the potential to improve milk quality due to increased palatability, enhanced herbage intake and improved nutrient balance. While higher fertiliser-N inputs on ryegrass-dominated swards are common on many conventional dairy farms in lowland regions, under the moderate-N inputs in organic systems other grasses including timothy, cocksfoot and meadow fescue are suited to specific environmental conditions and can produce yields comparable

with ryegrasses. For example, timothy grass is highly palatable, cocksfoot is suited for drier areas, and meadow fescue is productive on heavier soils in wetter regions. Herb species, either sown in new leys or maintained in permanent pastures, have a valuable role in organic diets due to their high mineral concentration. Chicory and ribgrass plantain are two herbs whose value has been recognised. However, the survival of herbs in a grazing sward is influenced both by the grazing strategy and by competition from more aggressive species in the sward.

The important role of permanent pastures

While many studies on organic milk production focus on the production of herbage from reseeded leys and the benefits of a crop rotation, the role of permanent pastures is also essential in many systems and their important contribution to the production of quality milk should not be underestimated. Many of these pastures contain a wide range of plant species that are adapted to the local environmental conditions. These pastures also affect milk quality, including influencing the production of milk that characterises individual cheeses with different sensory properties from lowland and upland regions, attributable to the range in the botanical composition of the individual pastures. In a long-term pasture where the botanical composition is stable, the optimum composition has been reported to be 50–60% grasses, 20–30% legumes and 10–20% other species. Maintaining a balance between different species in the sward will be influenced by both the stocking density and other management practices that have a major influence on the stability of the botanical composition and the potential of the pasture to provide herbage that leads to good milk quality.

Improving silage quality on organic farms

Silage is the main conserved forage fed to organic dairy herds during the winter housing period. It influences feed intake and the quality and quantity of milk produced. It is primarily made from clover and other legumes, ensiled either alone or more commonly in a mixture with grass species. As legumes have lower sugar contents and a higher buffering capacity than grasses harvested at a similar stage of maturity, wilting low DM crops prior to ensiling and the use of a biological additive will improve the fermentation process. Other crops for ensiling include forage maize and whole-crop cereals, with maize silage readily fermented without an additive due to the low buffering capacity and rapid decline in pH when the crop is ensiled.

While the nutritive value of ensiled crops is lower than that of the fresh material, ensiling at DM contents >23–35% will ensure that nutritive losses due to the production of effluent are minimised, and will also avoid the problem of leaf losses from high DM legume crops due to mechanical damage pre-ensiling. Silage made from leafy mixed grass and legume crops will lead to higher intakes and improved milk protein compared with ensiling more mature crops with high stem contents, due to a greater reduction in particle size from mastication and a more rapid rate of passage out of the rumen of the more digestible forage.

However, leafy crops have a lower DM content, require more wilting prior to ensiling and produce a lower yield per hectare than more mature crops.

11.3.3 Grazing strategies and the role of white clover

During the grazing season organic milk is produced from diets that are based partially or wholly on grazed herbage from mixed grass and white clover swards produced from both reseeded leys and permanent pastures. These swards have the potential to lead to higher intakes of herbage during the grazing season, due to the beneficial contribution of the clover plants and a greater persistency of quality that is attributable to the increasing proportion of clover as the grazing season progresses. Maximising milk production from grazed herbage has been found to improve milk quality when compared with diets based on conserved forages, including increasing vitamins A and E concentrations, carotenoid content and up to 500% more of the anti-carcinogen conjugated linoleic acid (Dhiman *et al.*, 1999). Milk quality is influenced by the quantity of available herbage and also the composition and maturity of the sward. Cows grazing leafy swards will produce milk with a higher content of conjugated linoleic acid compared with those grazing more mature swards with a high stem to leaf ratio (Bell *et al.*, 2006). Organic herds calving in the spring are well placed to benefit from grazing mixed grass and white clover pastures. However, it is widely acknowledged that achieving consistent levels of high quality milk is limited by the constraints of accurately determining the nutritive quality and intake of grazed herbage, and is more difficult when compared with diets based on conserved forages where the consistency of the quality and intake of the silage-based diets are often less variable. Therefore, organic farmers calving cows in the spring and producing the major part of the annual milk output from grazed herbage need to be aware of two key factors affecting production.

The first factor is the potential lack of milk persistency and shortened lactations that lead to a reduced output of milk quality components due to farmers being unable to accurately estimate both the nutritive value and actual intake from the herbage, leading to supplementary feeds being required to balance the diet and allow the cow to achieve her genetic potential. The intake of grazed grass herbage has been found to support milk yields of *ca.* 25 kg/day from cows consuming 15.0 kg DM/day (Mayne and Peyraud, 1996). However, to achieve milk yields of >30 kg/day from higher genetic merit cows, Kolver and Muller (1998) found that even with herbage intakes of 19 kg DM/day the inclusion of a supplementary feed was required, and Mayne and Peyraud (1996) concluded that to maximise herbage intakes the grazing strategy should include offering >18 kg DM of organic matter/day, or *ca.* 21–22 kg DM/day from a dense sward with a surface height of 12–14 cm. Ensuring swards are not grazed to a sward height below 7–8 cm also enables the cow to achieve satisfactory intakes by allowing the selection of the more nutritious plant parts. Organic swards with satisfactory clover content have the potential to increase herbage intakes above the levels achieved with pure grass swards but are still unlikely to

meet the requirements of the higher yielding cow. It is important to note that at the same sward height, the quantity of herbage per unit area on organic farms will be about 20% lower during the grazing season compared to those recorded on conventional dairy farms. Therefore, the stocking density on organic farms also needs to be lower to ensure optimal yields of quality milk are produced.

Protein changes in the composition of organic swards

The second factor is the change in the energy and protein concentrations of the diet as the ratio of grass to clover changes during the grazing season. The energy to protein balance of the diet and its influence on milk composition will be affected by simultaneous changes in both the botanical composition of the sward and protein content. While the optimum clover content in the total DM is approximately 30%, during the grazing season the proportion of white clover in a mixed grass and white clover sward increases, reaching a peak in midsummer that may result in up to 70% clover in the total DM content of an individual sward. In addition, there is a temporal change in the protein content of the sward throughout the grazing season, with the protein content of the white clover component increasing from 22 to 31% and the grass component from 11 to 24% (Weller and Cooper, 2001). By early July the protein in the herbage, including a high proportion of rumen-degradable protein, is significantly above the cow's nutrient requirements and will reach 25% by the autumn, potentially leading to poor protein utilisation by the cow as extra feed energy is required for urea excretion rather than being converted to milk protein. When herbage supply is plentiful, a preference for clover rather than grass plants will increase the intake of protein even further. For the high yielding cow receiving a buffer feed (e.g. silage or concentrate supplement) that has a high energy/low protein value, the diet can be balanced, but for cows not being offered a supplementary feed the protein content of the diet will be too high during periods of the grazing season. A failure to maintain the correct energy to protein balance in the diet, resulting in the intake of excess protein, affects milk quality both directly and indirectly due to reduced conception rates and a change in the annual calving profile of the herd.

Although grazed forages with a high protein content (organic high clover swards, conventional spring grass receiving a high fertiliser-N input) have been found to increase the protein content of milk, they also led to an increase in blood urea levels and a higher protein content in the diet can reduce reproductive efficiency and also increase lameness compared with lower protein diets (Butler *et al.*, 1996; Manson and Leaver, 1988; Plym Forshell, 1994; Chamberlain and Wilkinson, 1996). Therefore, the potential risk, irrespective of the calving pattern of the herd, when non-pregnant cows graze protein-rich swards, including grass/clover mixtures, and do not receive any supplement of a high energy/low feed or only a small quantity (e.g. spring calving organic herds), should be assessed. Measuring the urea content in the milk is a useful reactive indicator of when the diet reaches excess protein that leads to energy to protein imbalance.

The influence of stocking density and type of grazing system

Stocking density is also an important factor during the grazing season and has been found to affect the quality and processing characteristics of milk when grazed herbage is the sole feed. In managing grazing swards to maximise the level and quality of organic milk, changing the stocking density will affect the output per cow, with the effect being more significant for higher yielding cows. While increasing the stocking density leads to maximum milk output per hectare, yield per cow and output of milk solids are reduced and the risk of negative feed intake increased. To maintain milk quality and also avoid adverse changes in the botanical composition of the sward, either the total grazing area needs to be increased or the density of cows needs to be decreased during periods when herbage growth is slower.

Grazing systems used on organic farms include strip grazing the grass plus white clover swards with an electric fence, the rotational grazing of paddocks in a 28–35 day cycle, and the continuous grazing of the same area throughout the grazing season. The type of grazing system is unlikely to have a major influence on milk quality when compared with ensuring that the appropriate stocking density is maintained and that sufficient quantities of leafy, high quality herbage are available. However, a rotational grazing system has been found to lead to a more uniform pattern of herbage intake that will minimise the daily variations in the output and concentration of milk components. The leader/follower strategy within a rotational grazing system, where the highest yielding group of cows graze ahead of the lower yielding group, has the potential to minimise problems of feed energy deficiency by allowing the high yielding cows to selectively graze the more nutritious plant parts, resulting in an increase in both the quality and quantity of milk produced. Unless the appropriate stocking density is maintained during the grazing season, the proportion of clover can adversely decline when swards are continuously grazed, and a silage cut will become necessary in the later part of the summer when rapid clover growth occurs, to ensure the productivity of the sward and output of milk are sustained.

As the clover content of the grass plus white clover swards increases during the season, the fibre content of the total diet decreases, leading to the ingestion of more forage that is rapidly digested. This leads to an increased risk of bloat that occurs on some organic farms despite high standards of grazing management. The risk of bloat will be minimised by ensuring hungry cows never have access to clover-rich pastures and the herd has a similar quantity of fresh herbage each day, with additional sufficient long fibre also made available from other feeds. Both lucerne and red clover can be occasionally grazed to improve forage intake and quality when the productivity of grazing swards is low. For example, in France, lucerne varieties selected for persistency and grown in association with cocksfoot have proved to be successful under grazing management (Charrier *et al.*, 1993). However, there is a high risk of bloat to the herd and also declining yields when either crop is grazed frequently.

Buffer feeding as a management option during the grazing season

Seasonal changes in the quality and quantity of herbage from grazed swards are inevitable on organic dairy farms, often leading to significant challenges in relation to maintaining both the yield and quality of milk components. Variations in herbage availability, sward composition (e.g. grass to white clover ratio, DM content) and nutritional value occur throughout the grazing season, and any adverse effects of weather (wet and/or windy conditions, heat stress) on milk production can be minimised by offering a supplementary feed (concentrates, alternative forage) in addition to the herbage that is available. Offering a supplementary feed has the potential to minimise the risk of an imbalance in the protein to energy ratio of the diet and low dietary fibre and low milk protein concentrations.

Buffer feeding has the potential to overcome the problem of oversupply of protein relative to feed energy that occurs when grass plus white clover swards are grazed, with energy rich/low protein feeds such as maize silage, whole-crop cereal silage, fodder beet or concentrates – all suitable energy sources (Zollitsch *et al.*, 2004). The quality of the buffer feed is important, and Phillips (1988) reported that milk protein content can be reduced when grazed herbage is supplemented with silage that is of a lower quality than the grazed herbage.

A lack of fibre is a common problem in conventional systems when cows graze leafy grass pastures, leading to reduced saliva production and chewing activity, the risk of ruminal acidosis and a sharp reduction in the fat content of milk. White clover plants have markedly lower fibre contents than grass, and in organic systems fibre deficiency is likely to occur in the grazing season. The buffer feeding of palatable forage (good quality hay or silage) will provide extra fibre to minimise the risk of changes in milk quality.

11.3.4 Optimising feed quality with the cow's peak nutrient requirements

Whether milk is directly processed on the farm or sold to a milk cooperative, the aim should be to maintain a consistent quality throughout the year. The season of calving and the start of lactation within the herd have a direct influence on the supply and quality of organic milk during the year and can also have a major effect on the requirement for different forage and concentrate feeds. The types of feeds that are available during the early lactation period and the production costs per unit of milk are important factors to consider when deciding on the most viable calving season for the organic herd; however, the major factors influencing the decision are the destination of the milk from the herd and the effect of the calving season on the financial viability of the system.

To achieve a consistent output of milk throughout the year, a year-round calving season is the main choice for most organic dairy farmers, with the milk either sold directly on a regular basis from the farm or purchased by a cooperative for the liquid market. Therefore, the main priority is to produce a consistent quantity of high quality milk throughout the year, irrespective of the availability of individual feeds at specific times of the year. This is a particular

challenge in herds calving cows during midsummer when herbage growth is markedly lower. An alternative option to maintain a relatively stable output of milk throughout the year is to divide the herd into two separate groups, with the groups calving in short eight-week periods in both the autumn and spring. This results in the lower daily yields but higher milk solids of the cows in late lactation being balanced by the higher yields and lower milk solids output of the newly calved cows.

For those farms producing milk for the processing market or selling to larger cooperatives, there may be more flexibility in when the milk is produced, and this provides the opportunity to calve all cows within a short time period, for example block-calving within one annual eight-week period. This strategy offers two choices, with the more extensive systems feeding a low proportion of concentrates to spring calving cows and maximising the output of the annual milk production from grazed herbage, while more intensive systems block-calve in the autumn period and feed diets based on a combination of conserved forages to complement grass plus clover silages and a greater proportion of concentrates in the total diet. A spring calving season offers the opportunity of minimising feed costs as the cow's peak nutritional requirement is more easily matched by the availability of the cheapest form of forage, i.e. high quality fresh herbage during the main part of the growing season.

To maximise the utilisation of the high quality herbage for milk production requires the cows to calve prior to changing from a diet of conserved forages fed indoors to grazing high quality herbage. However, spring-calving cows are more vulnerable to the adverse effects of less favourable and unpredictable weather conditions during the spring on milk yield and quality, yield persistency and total lactation yield, due to a more erratic pattern of daily DM intake, reduced milk fat concentrations and higher somatic cell counts. Systems based on the block-calving of the herd in the autumn have the potential to produce higher yields of milk solids from more consistent daily feed intakes and achieve greater milk persistency compared with spring-calving herds, as the diet can be more carefully controlled. However, the system is dependent on feeding a higher proportion of concentrates in the diet, producing high quality conserved forages to ensure adequate intakes are achieved, and an acceptance that the production costs per unit of milk are higher than for milk produced from grazed herbage.

11.3.5 Minimising the risk of health and welfare problems

Somatic cell counts

High standards of hygiene and animal husbandry are critical in all dairy systems. In organic systems where herd health status is achieved without the routine use of conventional medicines, the standards need to be extremely high to minimise the risk of health problems in the herd and ensure high quality milk is produced. The importance of high standards was reported by Ellis *et al.* (2007), who found that cow cleanliness in organic dairy herds had a greater negative influence on milk somatic cell counts compared with conventional herds. Increases in the

occurrence of individual health problems, including both clinical and sub-clinical mastitis, have the potential to adversely affect on milk quality. A number of surveys of the health status of organic dairy herds have shown that in practice some organic farms manage to achieve high standards and a low incidence of problems, while others find controlling herd health more challenging. It is essential to employ fully trained staff committed to maintaining high standards of husbandry within the standards defined for organic milk production to minimise the risk of both contagious (e.g. *Staphylococcus aureus*) and environmental pathogens affecting herd health and milk quality, irrespective of the size of the herd or the type of management system.

An important challenge for organic dairy farmers is to ensure that somatic cell counts in the milk are maintained at a satisfactory level, as a high cell count is an indicator of the health status of the udder, with both Renau (1986) and Urech *et al.* (1999) reporting that healthy cows have an average of <200,000 cells/ml. High cell counts reduce the stability of the milk and its shelf-life. Processing milk with high cell counts results in increased costs due to the loss of yield (casein) during the cheese-making process and reduced quality due to increased proteolysis during storage (Auldust *et al.*, 1996; Klei *et al.*, 1998; Ma *et al.*, 2000).

Housing cows in straw-bedded yards rather than cubicle sheds is a standard practice on many organic dairy farms and increases the risk of mastitis and higher levels of somatic cell counts due to environmental pathogens, with *Streptococcus uberis* the main pathogen (Blowey and Edmondson, 1995). Krutzinna *et al.* (1996) reported that the somatic cell counts were significantly higher when organic herds were housed in straw yards rather than cubicles (352,000 vs. 258,000 cells/ml). Weller and Bowling (2000) also reported markedly higher average cell counts for organic herds housed in straw yards (275,000 cells/ml) compared with the lower cell counts (216,000 cells/ml) of herds housed in cubicle sheds. In both studies there were large differences between herds in the average somatic cell content of the milk, with the average cell count from many organic herds above the threshold at which a decline in cheese quality and yield occurs. Key factors to maintain low cell counts when herds are housed in straw-bedded yards include frequent renewal of adequate quantities of straw and the complete cleaning out of the yards at frequent intervals during the period of housing.

Metabolic disorders

The risk of negative energy balance is critical during early lactation (Duffield *et al.*, 1997; Heuer *et al.*, 2000) and can lead to both clinical and sub-clinical ketosis. The magnitude of the negative energy balance is potentially greater in organic systems feeding high forage diets. This is attributable to an imbalance between the cow's nutrient requirement and the energy density of the diet, and also the lower energy density of forages compared with concentrate feeds. Providing a balanced diet with sufficient metabolisable energy is essential to prevent excessive mobilisation of body fat (Roepstad *et al.*, 1989), suppression

of the immune system and an increased risk of ketosis that not only leads to lower milk quality and yield but also predisposes the cow to the occurrence of secondary health problems, including lameness, mastitis and infertility. In addition, ketosis affects the financial viability of the organic herd due to a reduction in milk income and an increased culling rate due to infertility, particularly when silage diets are fed. The results from a number of studies show that the risk of ketosis problems is reduced by feeding >5 kg of concentrates/day and including only high forage levels in the diet, including forage maize, fodder beet or fresh herbage from leafy swards (Weber *et al.*, 1993; Vaarst and Enevoldsen, 1994; Weller and Bowling, 2004).

Reducing stress and behavioural problems

In organic systems there is a need for a high standard of management to ensure that the feeding of high forage diets does not increase the potential risk of stress that can lead to both primary and secondary health problems and a decline in milk quality. Milk quality can be adversely affected by stress, including an increase in somatic cell count levels and lower protein concentrations. Factors increasing stress include sudden environmental changes (e.g. the change from housing to grazing), the occurrence of adverse weather, sudden dietary changes (from pre- to post-calving diets) and behavioural problems associated with either inadequate feeding facilities or mismanagement of groups within the herd.

Studies have shown that a significant proportion of the health and stress problems in a dairy herd occurs during the six-week transition period from pre- to post-calving, potentially adversely affecting milk quality for a significant period after calving. The transition period often includes a marked change in the type and quality of ingredients that are fed to the cow post-calving. Both the physical stress of calving and the need of the digestive system to adapt to the changes in the diet need to be considered when the pre- and post-calving organic rations are formulated, as both the type of diet fed during the dry period and the adaptation of the digestive system from the pre-calving to post-calving diets influence the performance of cows in the subsequent lactation (Goff and Horst, 1997; Ryan *et al.*, 2003). During this period the periparturient diseases that occur in conventional dairy systems also occur in organic systems (Bosberry and Dobson, 1989; Offerhaus *et al.*, 1994; Weller and Bowling, 2000), including milk fever, retained foetal membranes and endometritis.

As organic herds increase in size the risk of stress to the individual animal, particularly first-lactation heifers, from social dominance and increased competition between cows becomes more important, including problems of displacement from the feed barrier and reduced forage intake. Avoiding large numbers of cows within each group, restricting the transfer of cows between groups, separating mature cows from first-lactation heifers, reducing the stocking density and increasing the available width per cow at the feed barrier (silage-based diets) or electric fence (strip grazing) provide options for maximising forage intakes within the herd and ensuring quality milk is produced.

11.3.6 Genetics compatible with organic systems

When selecting a suitable type of cow for an organic system, the farmer needs to consider the type of management system and whether the diversity of crops being grown and the degree of reliance on imported feeds will provide diets to achieve the production of quality milk from higher genetic merit cows or are more suited to lower genetic merit cows producing quality milk from lower lactation yields.

Producing quality milk in more extensive organic systems whose strategy is to produce <6000 litres of milk per cow, primarily from grazed herbage supplemented with minimal concentrate supplementation (<0.5 tonnes per cow), including 5000 litres from the forage component of the diet, will generally be more achievable from cows of lower genetic merit. In more intensive organic systems aiming for higher yields per cow (>8000 litres), high quality milk can be produced from diets based on mixed grass plus legume silage that are nutritionally improved by the inclusion of high energy-rich forages (fodder beet, maize silage) and a higher level of concentrate supplementation (>1.5 tonnes per cow). In these systems, high genetic merit cows are able to efficiently produce high quality milk, as feed energy supply will be optimised by both the range of energy-rich forages and the higher proportion of concentrates that can be included in the diet, leading to both the magnitude and length of the post-calving negative energy balance being minimised (Knaus *et al.*, 2001; Weller and Bowling, 2004).

Within some European countries with larger-scale dairy systems, organic milk production has been dominated by breeds that have been selected and bred for more intensive conventional systems in which a higher proportion of concentrates is included in the annual diet. For example, in both the Netherlands and the UK the high genetic merit Holstein breed is either the sole or the main breed in the majority of organic dairy herds. However, while the Holstein has performed well in systems feeding a higher proportion of concentrates in the diet, the potential benefits from other breeds and also crossbreeds are currently making an increasing contribution to the total production of organic milk in less intensive systems, including ensuring that milk quality components are maintained at a satisfactory level throughout the year, and that the productive life (i.e. longevity) of cows within the herd is increased due to improved reproductive status. For example, in Switzerland successful breeding programmes have been achieved with both the Brown Swiss and the Swiss Red and White breeds to improve the compatibility between genetics and the system of management (Bapst, 2001). In the UK the potential benefits of cows with a less demanding nutrient requirement, including the Ayrshire, Guernsey, Jersey and Shorthorn traditional breeds, are now widely recognised.

However, when comparing the suitability of dairy breeds with different genetic merit values for organic systems, it is important to note that in a study comparing the performance of high genetic merit cows in both low and high concentrate input systems (Weller and Bowling, 2004), there were marked differences in performance between individual cows in both systems. For

example, the majority of cows maintained satisfactory yields, milk quality and reproductive efficiency when fed <0.5 tonnes of concentrates per lactation, but metabolic disorders, a high milk fat to protein ratio and delayed conception also occurred with some cows due to a feed energy deficit. It is important to note that despite the differences found between the Holstein–Friesian cows in the above study, genetic variation is likely to be greater between breeds than within breeds.

Differences between breeds may be important within self-sufficient organic systems, as the diets are potentially more vulnerable to mineral deficiencies that can affect the health status and performance of the organic cow. For example, Bakke (2003) reported that Jerseys, Norwegian Reds and Swedish Red breeds are more prone to milk fever, and in the USA farmers are advised to include extra calcium in the diets of Jersey cows. Roderick and Hovi (1999) also reported a higher incidence of milk fever in coloured breeds compared to black and white cows. Jerseys are also susceptible to copper toxicity, which is a problem when high molybdenum concentrations occur in forages grown under stressed conditions, e.g. periods of low rainfall and slow rates of plant growth.

Optimal lifetime efficiency has been reported as being achieved when cows have a productive life of six lactations (Webster, 2000; Moorby *et al.*, 2003), attributable to lower culling rates and a better ratio of productive to non-productive cattle due to the requirement for fewer replacements. Longevity is an important factor in organic dairy herds; it has both benefits and disadvantages, including the influence on milk quality, and is often attributed to the differences between dairy breeds. Benefits of longevity include improved financial margins per hectare and improved welfare standards associated with the cow having a longer productive life, while the disadvantages include lower immunity status, a higher risk of disease with increasing age and reduced milk quality, particularly high somatic cell counts, lower total protein and a decrease in the casein to non-casein ratio. The somatic cell counts in the milk of older cows within an organic herd are markedly higher than those in younger cows (Weller and Davies, 1998). Therefore, while the aim may be to extend the productive life of cows, in some herds older cows have to be culled to keep the average somatic cell count at a level that meets acceptable standards for both the liquid and processing markets.

11.4 Future trends that may influence the quality of organic milk

Concerns have been expressed that the increases in the size of dairy units that are occurring in both conventional and organic systems in some countries may have an adverse effect on welfare standards and milk quality. However, increasing herd size is an inevitable change for many countries and cannot be classified as either beneficial or detrimental, as the production of quality organic milk from well-managed herds with a good health status is dependent on the standards of management and husbandry, not on the number of cows *per se*. For

example, the production of high quality milk is achieved successfully in Danish organic herds even though many of the farms operate large organic units.

The minimum standards defined for the quality of milk produced on dairy farms have been raised in recent years. Further changes, including the requirement to reduce the average herd somatic cell count, will not be of concern to the majority of organic farmers. However, for others any reduction of cell count will require investigation of the causes of high cell counts, and will necessitate either an improvement in the current management and husbandry practices or the culling of a higher proportion of the herd, due to sub-clinical infections causing the high cell counts of individual cows.

The increasing demand in the future for nutrients, fossil fuels and water for the production of milk and other food products will increase the need to produce quality milk from more sustainable systems, and the challenge will be to grow high quality forages within the farm system and to utilise them more efficiently. The greatest changes are likely to occur where significant quantities of feed need to be purchased to maintain a more intensive system, with the increasing demands for grain crops for human consumption, biofuels and monogastric animals also likely to increase the cost of purchased concentrate feeds to an unacceptable level.

Future climatic changes will also influence the type of crops that are grown on organic dairy farms if a viable level of high quality milk is to be maintained. Areas with increasing rainfall and milder winter temperatures are likely to benefit from an enhanced performance from the grass and white clover swards. This will have a positive effect on milk quality due to an extended grazing season and a greater proportion of fresh herbage in the annual diet. However, areas experiencing reduced annual rainfall will need to maintain the current annual quantity and quality of herbage by growing alternative crops to compensate for the lower production from the grass and white clover swards, including growing deeper-rooted crops that include chicory and lucerne. Replacing spring-sown with autumn-sown crops that reach acceptable yields prior to low summer rainfall periods, including whole-crop cereals and grasses with early spring growth, will also have an important role in the cropping strategy.

11.5 References

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